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ABSTRACT

This curriculum guide contains course content for a series of "mini-courses" that can be presented in an adult continuing education program in area technical-vocational schools and community colleges. The program consists of nine modules, each divided into units and including learning objectives and student handouts. The modules cover the following areas: (1) awareness of the energy dilemma--an introduction and prerequisite for the other courses; (2) surveying energy usage--a brief assessment of the energy used in the United States by the various energy-user categories; (3) utility bills and economics of energy conservation--a discussion of energy pricing, the development of power utility rate structure, and natural gas rate fluctuations; (4) how to search for energy conservation opportunities--a presentation of opportunities for the individual and the community to save and to conserve energy in the automobile, the home, and the use of appliances; (5) lighting conservation opportunities--lighting for energy conservation; (6) hot water heating conservation opportunities--techniques for selecting, installing, and operating the domestic hot water heater; (7) appliance energy conservation opportunities--techniques for purchasing, operating, and maintaining appliances; (8) building construction versus energy consumption--factors involved in building an energy-efficient home; and (9) heating, ventilating, and air conditioning conservation--principles of heating and cooling buildings. Lists of printed and audiovisual resources are included. (KC)

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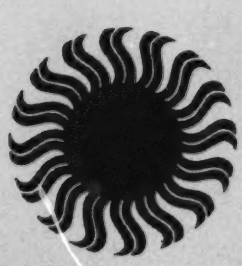

Energy Awareness Curriculum 1980

CE028002

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Nelson W. Dutton
Alternate Energy Instructor

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President

MODULE #1

AWARENESS OF THE ENERGY DILEMMA

MODULE DESCRIPTION:

This module discusses some of the aspects of the energy problem, including a few of the general causes for its development. The magnitude of the crisis is touched upon and a survey is made of the obstacles that lie ahead.

GOAL STATEMENT:

The objective of this module is to increase the ability of the student to help in solving the energy problem that faces the world today.

MODULE #1

AWARENESS OF THE ENERGY DILEMMA

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MODULE #1

AWARENESS OF THE ENERGY DILEMMA

INTRODUCTION

Every solution to the energy crisis has its defenders, and for every choice which is made a price must be paid. The supposed "dilemma" posed by the two principal solutions--conservation and greater use of solar-related energy sources, on the one hand, and development of known oil and gas reserves, new coal or nuclear technologies on the other--may not really be a dilemma at all. Perhaps, that is, we may not be forced to choose between these suggested "options". But whatever course is followed, advantages as well as disadvantages follow. The conservation, small-scale technology path does not seem to be able to sustain our massive industrial system and could lead to significant economic and employment problems as well as what would seem to be a very different way of life from that we now lead. Unimpeded development of domestic oil and gas reserves ultimately would only serve to increase our dependence on foreign sources. Use of other sources of energy, principally coal and nuclear energy, involve grim environmental costs and public safety and health hazards.

What are the "special interests" which have high stakes in the kind of decisions to be made? What price must be paid

for the various "solutions" which have been proposed? What, for example, would it take for me to abandon the use of my car? How heavily should we gamble on technological breakthroughs? What are the trade-offs between: conservation and jobs; economic growth and a clean, safe environment; government regulations and free enterprise; self-interests and the common good; and local or regional interests and national needs? Is there any solution to our energy problems satisfactory to all? If not, how can a compromise be reached? Who should make the compromises?

Community colleges and area vocational-technical schools have important roles to play in the "search for solutions" associated with current and future energy production, use and conservation. A careful examination of needs, concerns and appropriate technology leads to the following conclusions:

A concerted effort should be made to inform communities of the nature of the energy crisis and the prospect of its partial alleviation through energy conservation and the use of appropriate technology.

An urgent effort is needed to bring the United States and its people out of the energy fantasy land, where everything is all right and everything comes out well in the end. The magnitude of the problem envolves everyone.

Community colleges and area vocational-technical schools

are in a unique position to address the previous issues. The mission, stature, experience, and outreach capabilities of these schools are compatable to such a role. They are aware of local needs, concerns, resources and skills. They are in contact with relevant local agencies, organizations, and institutions. They have traditionally fulfilled a community education function.

PROGRAM OUTLINE

Module 1. Awareness of the Energy Dilemma

Module 2. Surveying Energy Usage

Module 3. Utility Bills and Economics of Energy Conservation

Module 4. How to Search for Energy Conservation Opportunities

Module 5. Lighting Conservation Opportunities

Module 6. Hot Water Heating Conservation Opportunities

Module 7. Appliance Energy Conservation Opportunities

Module 8. Building Construction Versus Energy Consumption

Module 9. Heating, Ventilating, and Air Conditioning Conservation

These nine modules can be presented as individual mini-courses in the program of continuing education. While the individual modules can be presented individually, it is recommended that completion of "Module 1" be a prerequisite for the other modules.

AWARENESS OF THE ENERGY DILEMMA

UNIT I: GROWTH OF ENERGY DEMAND

HANDOUT 1: CAUSES

POPULATION INCREASE

The population of the world will reach six billion by the year 2000--almost twice the current population. (At the present growth rate of two and one-half percent, the doubling time for population is 28 years.) If energy demand increased along with population, twice as much energy would be needed by 2000. In fact, energy demand is growing faster than population and the need to triple the world energy supply is anticipated. The energy demand of countries outside of the United States has just begun to accelerate.

LIFE-STYLE U.S.

Cheap energy has been the spoiler in the American energy life-style and now it is time for a reckoning. A change-over was made from shipping by railroad to shipping by truck, yet trucks use 5.5 times as much energy per ton mile as railroads use. Truck companies made better profits than railroad companies--when energy was at a token price. Airplanes are being used to carry much of the freight shipped, yet the airplane uses 11.0 times the energy of trucks per ton mile. Airlines

made more profits than trucking services--before fuel prices soared.

It has been less expensive to build a building to satisfy the eye-appeal of a customer and let low-cost energy overpower the weather. Result--80% of our buildings use much more energy than necessary. Some are energy disasters.

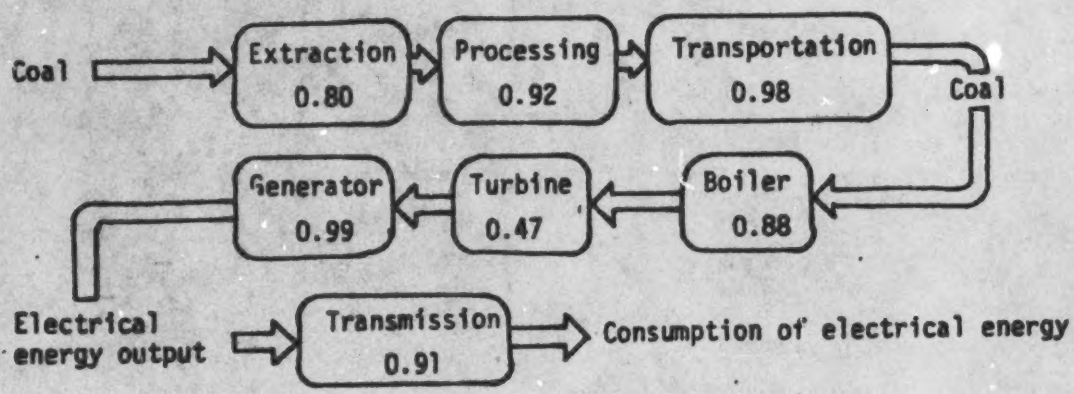
The U.S. industry used 120 million BTU to make a barrel of cement at a time when Western Europe and Japan were using about .55 million BTU per barrel for the same process. Low-cost energy in the U.S. made it uneconomical to construct an energy conserving model of a cement kiln, such as those used in Japan and Western Europe.

Some of the other life-style changing factors include the economic boom of the 1960's which resulted in a high level of surplus income, most of which was spent on energy-consuming luxuries. Second cars, motor homes, snowmobiles, speedboats --all became a way of life for United States citizens. All used large amounts of energy, both in the manufacturing process and for operation. The demand for leisure time resulted in major changes in industry and agriculture with a decrease in tedious labor at the expense of increase in the use of energy.

The actual implementation of pollution controls on industry required the expenditure of large amounts of energy. At the same time that energy demands were increasing, restrictions were placed on the supply of energy.

ELECTRIC POWER GENERATION

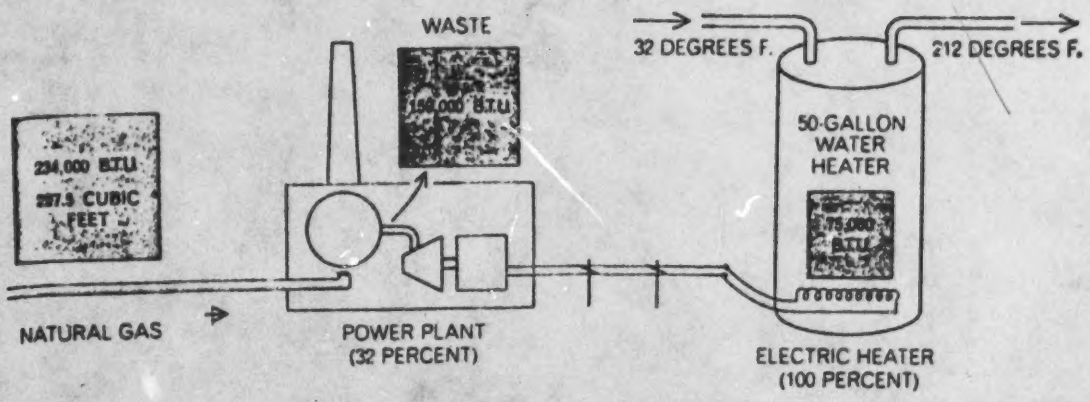
Electricity is necessary for lights, electronics, small motors and etc.. Should it be used for heating purposes?

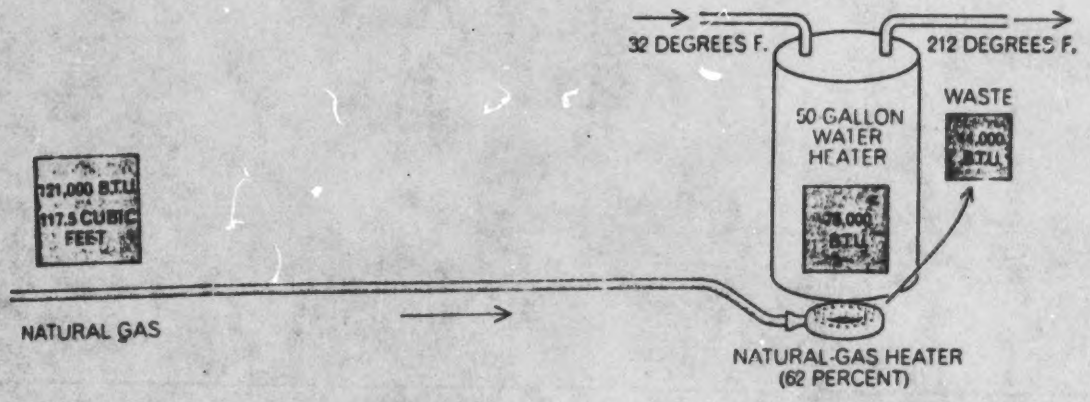


There are energy losses at each stage of energy movement. The average efficiency of each step is shown. The overall efficiency is the product of each step. The overall efficiency equals 26.8%

As illustrated on the following page, efficiencies of heating water with natural gas indirectly by generating electricity for use in resistance heating (top diagram) and directly (bottom diagram) are contrasted. In each case the end result is enough heat to warm 50 gallons of water from 32 degrees Fahrenheit to 212 degrees. Electrical method requires substantially more gas even though efficiency at electric heater is nearly 100 percent.

Study the two diagrams below simultaneously.



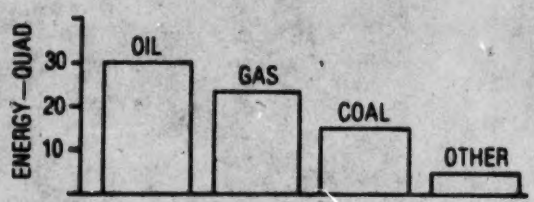


AWARENESS OF THE ENERGY DILEMMA

UNIT I: GROWTH OF ENERGY DEMAND

HANDOUT 2: MAGNITUDE

The United States consumed more than 73 quadrillion BTU of energy in 1977. A quadrillion BTU is called a quad. It takes 7½ billion gallons of gasoline or about 46 million tons of coal to produce a quad of energy. Approximately 41 percent of the total energy was produced from oil. About 32 percent was produced from natural gas. About 19 percent was produced from coal, and about 8 percent from other sources such as nuclear and hydroelectric generating plants.



Of the sum total of oil used in 1977, around one-half of it was imported. The cost was about 32 billion dollars. This is money that has left the country. It is money that cannot be spent for developing a more energy-efficient transportation system. It is money that cannot be used for developing new energy sources. Had this money been applied toward such developments, the U.S. could become less dependent on the world energy supply. That 32 billion dollars also poses a grave

drain on the country's balance of payments. More dollars are leaving than are returning.

So, what about the future? Suppose, for instance, energy consumption in the U.S. keeps growing at the same rate that it has for the past 30 years. And suppose that this demand will be met with fossil fuels as in the past. Many would like to believe that this is possible. It is not. At the same rate of growth, the U.S. energy needs would triple by the year 2000. Enough fuel would be needed to produce 200 quad of energy. Such growth is not likely to happen. A more realistic projection is about double the current usage or around 145 quad.

Some optimistic projections for energy sources in the year 2000 are: about 32 quad from oil, 15 quad from natural gas, perhaps as much as 30 quad from coal, about 10 or 11 quad from nuclear power plants, and about five quad from hydroelectric power plants. That adds up to about 93 quad of energy, short of the estimated demand by about 52 quad. To expect that enough energy sources will become available to cover a projected shortage of 52 quad is unreasonable. Being optimistic will not run your car.

The oil embargo of 1973 created a one-quad shortage. It resulted in the most serious economic recession that this country had experienced in 40 years.

The gas shortage in the winter of 1976 was less than one

quad. It closed plants across the country and put more than one million workers off the job.

OTHER MAGNITUDE COMMENTS

If the U.S. oil imports were cut to 8.2 million barrels per day (a barrel is 3 feet long), end to end those barrels would reach 4600 miles.

The U.S. spent 38 billion dollars for imported oil in 1979. For a better concept of 38 billion dollars, picture this amount of money in one dollar bills and stacked. The stack, measuring 100 bills per inch, would reach 6000 miles high.

If all of the nation's gasoline storage tanks were full, there would be a 20 to 30-day supply on hand. Do full tanks make the energy problem vanish?

The United States imports nearly one-half of its oil needs and much of that supply can be cut off at any time. Think!

AWARENESS OF THE ENERGY DILEMMA

UNIT II: GROWTH OF ENERGY SUPPLY

HANDOUT 1: PRESENT SUPPLY

At present and in the near future the major portion of our energy supply must come from known and developed technologies. Traditionally, it has taken twenty to thirty years from the development of a new technology to its commercial application and there is no evidence that this time period can be significantly shortened. For the next twenty-five years the energy supply must come from fossil fuels, hydroelectric dams, and nuclear reactors.

PETROLEUM

Any consideration of oil as an energy source raises the question of the impact on the economy of large payments for foreign oil and the environmental dangers posed by large scale off-shore drilling. Also, there is a great deal of controversy over the amount of oil that is available on earth. While the major oil companies claim that supplies are dwindling, others say that the lack of reserves has come about because the oil companies are lax in the search for oil. However, whether oil will run out in fifty or two hundred years, oil, without question, cannot be regarded as a long-term

future energy supply.

NATURAL GAS

While there is also controversy over the available amount of natural gas, there is general agreement that it is the most limited of the fossil fuels. U.S. reserves have been lessening steadily for the last ten years and natural gas shortages have already been experienced in some areas of the country. The more optimistic estimates suggest that natural gas will be essentially gone within thirty years--pessimists say ten years. Natural gas is definitely not a long-term future energy source.

COAL

Large, low-sulfur coal fields in the United States are found in the western states--Wyoming, Montana, and Colorado. Many of these fields are found near the surface and are suitable for strip-mining. The strip-mining of these coal deposits is meeting opposition from many citizens of the states involved. The main concern of the citizens is the environmental impact of strip-mining. There has been some success in eastern states with the restoration of stripped land to beneficial use. However, in the water-short West, restoration is still in the experimental stage. Until this matter is resolved, resistance to strip-mining will continue.

For deep-mining to provide large amounts of coal in the future, new methods of mining must be developed that are not dependent on a large labor force--few people seem to be willing to become coal miners. A large increase in the number of mining engineers will be required. There is also the problem of coal supply. While the United States has large quantities of coal, the supply is not infinite, and the cost of extracting coal goes up rapidly as the supply is exhausted. When all the facts are considered, the production of large quantities of coal is not a simple task.

NUCLEAR FISSION

The potential for the supply of electrical energy from nuclear fission has already been well demonstrated. At the present time, about nine percent of our national electrical energy demands is satisfied by nuclear energy. It is anticipated that, by 1985, nuclear reactors will be producing almost twenty percent of our electrical energy and, by 2000, fifty percent. This anticipated growth of nuclear generation raises some serious doubts and fears in the minds of the public. These must be calmed through education, if the industry is to grow as expected.

Present reactors can use only about 0.7 percent of natural uranium as fuel. Current uranium reserves can be expected to supply present and future reactors past the year 2000. By the time these reserves are depleted, the breeder reactor,

which converts the remaining 99.3 percent of the unusable uranium into a useful fuel, plutonium, should be in line. The breeder reactor promises a nuclear fuel far into the future, perhaps as much as a thousand years.

The nuclear power industry has a remarkable safety record. To date there has not been a single injury or death attributable to radiation in a commercial power plant. The industry has accumulated 175 reactor-years of operation and the U.S. Navy has 1300 reactor-years of operation, all without a single accident.

Despite this impressive safety record, there is a segment of the public that is demanding a halt in the construction of new reactors and a shutdown of those already operating because they are "unsafe". A horrible scenario is envisioned by the critics of nuclear power in which a reactor explodes. Nuclear material is scattered through the air, and millions die. In fact, there have been some serious accidents at nuclear power plants and in every case the multiple-redundant safety systems closed down the reactor with no human injury and no leakage of radioactive materials. An exhaustive study of nuclear technology was completed in 1975, known as the "Rasmussen Report" --after the scientist in charge of the study. The conclusion of the study is that the probability of being killed by a nuclear reactor accident is less than the probability of being

struck by a meteorite--about one chance in 300,000,000. In contrast, the probability of being killed in an automobile accident is about one chance in 4,000.

Nuclear power plants produce small quantities of highly radioactive waste that will require long-term storage. A technique has been developed to convert this waste into a solid glass-like material that can be easily stored. As yet, the site for long-term storage has not been selected, but by the time appreciable amounts of wastes accumulate, twelve to fifteen years from now, it is expected that a satisfactory storage site will be available.

HYDROELECTRIC

Hydroelectric power has traditionally been thought of as a "clean" form of energy in that it causes no emissions. However, it is not without environmental effect. The creation of a large lake out of what was previously a free-flowing river causes environmental changes resulting in the death of some species and the growth of others. There is also evidence that the creation of large lakes can cause climatic variations over wide areas. The "wild rivers" legislation has been passed to protect some rivers and the public is increasingly opposed to large hydroelectric projects. Even if we ignore these considerations, the potential contribution of hydroelectric power in the United States is small. If every possible

river were dammed, less than four percent of our estimated electrical needs in the year 2000 would be met.

SUMMARY

In the next ten to twenty years our energy will have to come from known technology. The fossil fuels--primarily coal, nuclear, and hydroelectric are currently available. All of these technologies are in use today and are safe and reliable. We cannot afford to ignore or to prohibit any one of the three without serious consequence to production of goods and services. Conservation of energy will serve to reduce the anticipated shortages of energy and to provide a little more time for the development of long-term energy technology.

AWARENESS OF THE ENERGY DILEMMA

UNIT II: GROWTH OF ENERGY SUPPLY

HANDOUT 2: FUTURE SUPPLY

Energy for long-term use will come from technologies which are now being developed or perfected. The breeder reactor has been previously mentioned as a means of extending nuclear fission into the future. Several other technologies will now be mentioned. While this list is not all-inclusive, it illustrates the kinds of energy sources that are being considered.

NUCLEAR FUSION

Nuclear fusion is the reaction that occurs in the sun and involves the joining of two atoms of heavy hydrogen (deuterium) to form an atom of helium. When this occurs, at a temperature of over ten million degrees, a large amount of energy is released. The problem is the controlling and containing of this reaction to make it occur slowly enough so that useful energy can be obtained. To date, efforts to carry out a controlled nuclear fusion reaction in the laboratory have been unsuccessful. The problems are significant and it is possible that nuclear fusion may never be successfully utilized. If experiments do succeed (some are predicting

success within ten years), the generation of useful energy will still be many years in the future.

WIND

Wind energy is one of the oldest forms of energy used by man, having been used since biblical times for moving ships and since the fifteenth century for powering machinery. For certain isolated locations, where conventional electrical energy is unavailable, wind power is already being used. However, the feasibility of generating significant amounts of energy for national needs has not been demonstrated. To generate two megawatt requires a windmill about 160 feet in diameter on a 100 foot tower, with an average wind velocity of 27 miles per hour. Thousands of towers would be needed to replace one coal generating plant. Recently, a large-scale demonstration wind generator has been built but the technology is still several years from being perfected. While wind may be utilized in some portions of the country, it is unlikely to be significant in meeting our needs in the near future.

GEOTHERMAL

Geothermal power generation utilizes the heat of the earth to produce steam to run turbines. Theoretically, the extent of geothermal energy is unlimited. However, practically, there are limitations to its use. Geothermal steam produces

several environmental effects. If dry steam is obtained, a rare occurrence, problems come from noxious gasses that are found with the steam. Hot geothermal water is extremely salty, containing as much as twenty percent dissolved salts (ocean water contains about three and one-half percent). The disposal of this water is a problem, since it is much too salty to be dumped into streams. The water can be reinjected into the earth when cool, but this requires using some of the energy that was generated. In some areas pumping out large quantities of water has caused the land to sink. Finally, useful geothermal energy is found only in a few locations. The geysers steam field near San Francisco, California is the only large developed geothermal site in the United States. Its capacity of 400 megawatts is less than ten percent of the area's energy needs. Because of the many problems encountered, geothermal energy must still be classified as in the "development" stage.

SOLAR

Solar energy represents a potentially large energy source. One-half of one percent of the land area in the United States receives enough radiation to supply all the energy we need in the year 2000. Technically, it is possible to utilize solar energy to generate electricity, heat homes, and produce steam. The major problem is that solar energy is diffuse and is

received on the earth's surface at low intensity. A 100 megawatt solar thermal power plant requires over a million square feet (23 acres) of collectors. The technological design of such a power plant is now being investigated and the next few years should result in determination of the feasibility of large-scale solar electricity generation.

Organized efforts on the use of solar energy for home heating have been going on since the 1940's. However, it is only recently, with the sudden increases in the cost of fossil fuels, that large scale efforts have been made toward developing this technology. In some areas where fuel costs are high, solar heating can compete successfully today. As fuel prices rise and the technology improves, solar heating will play an increasingly larger part in meeting future energy needs.

A reasonable goal by the year 2000 is for one-third of new construction and one-third of old construction to be fitted with solar heating systems. One must be cautiously optimistic about solar heating since, if this goal is met, the energy supplied by solar heating would be only about five percent of the national energy used.

SUMMARY

The table on the following page is a summary of some future energy choices and their likely impact. It must be observed that our choice seems not to be "which resource should

be developed" but rather "how can we develop all our resources and encourage conservation to avoid serious energy shortages?"

ENERGY SOURCE	DEVELOPMENT STATUS AND PROSPECTS FOR FUTURE USE
FOSSIL FUELS	
Petroleum	Now widely used. Supplies limited--possibly exhausted in 30 to 40 years
Natural gas	Now widely used. Supplies limited--possibly exhausted in 10 to 20 years
Coal	Now widely used. Some difficulty in extracting --possibly exhausted in 300 to 500 years
HYDROELECTRIC	Now in use. Number of sites for future development is limited
SOLAR	Now in limited use. Needs further technological development. Practicality somewhat dependent on geography, weather patterns, etc.
NUCLEAR	
Conventional fission react.	Now in limited use. Low-cost fuel supply possibly exhausted in 30-40 years. Waste disposal problems
Fast breeder reactors	Now in late stages of development. Greatly extends potential fuel supply of fission reactors. Waste disposal problems
Fusion reactors	Feasibility still to be proven. Fuel supply virtually unlimited
GEOTHERMAL	Now in very limited use. Number of suitable sites for future development is limited
WIND	Now in very limited use. Needs further technological development. Number of suitable sites for future development is limited

MODULE #2

SURVEYING ENERGY USAGE

MODULE DESCRIPTION:

This module presents a brief assessment of the energy used in the United States by the various energy-user catagories. The residential sector is further subdivided in order to give an individual a better comprehension of the magnitude of personal energy usage.

GOAL STATEMENT:

The objective of this module is to give the student an overall concept of national energy usage and a detailed estimate of his personal consumption.

MODULE #2

SURVEYING ENERGY USAGE

UNIT I: Energy Demand 2-2

Handout 1: United States 2-2

A. Non-energy 2-3

B. Industrial 2-3

C. Transportation 2-4

D. Residential/Commercial 2-4

2: Household 2-5

A. Fuel Consumption 2-5

B. Food Preparation 2-5

C. Food Preservation 2-6

D. Laundry 2-6

E. Comfort Conditioning 2-7

F. Home Entertainment 2-8

G. Automobiles 2-8

H. Miscellaneous 2-9

SURVEYING ENERGY USAGE

UNIT I: ENERGY DEMAND

UNIT OBJECTIVE

Upon completion of this unit the student will be able to discuss energy demand of the United States in general terms and energy demand of the individual in more detailed terms.

SPECIFIC OBJECTIVES

Upon completion of this unit, the student will be able to:

1. Predict national energy consumption and energy usage growth.
2. Discuss personal energy usage.
3. Discuss the energy-consuming role of manufactured materials.

SURVEYING ENERGY USAGE

UNIT I: ENERGY DEMAND

HANDOUT 1: UNITED STATES

Total United States energy demand is projected to increase from 38 million barrels per day oil equivalent in 1977 to 51 million barrels per day in 1990. Higher energy costs, conservation efforts, and slower economic growth over the forecast period will cause the growth in United States energy demand to average around 2.3% annually, compared with 4.1% during the 13 years prior to the 1973 embargo.

Based on the previous assumptions, the following table gives the United States energy demand by consuming sector.

MILLION BARRELS/DAY OIL EQUIVALENT

	1960	1977	1985	1990
Nonenergy	1.9	3.0	3.9	4.4
Industrial	8.0	12.4	14.9	17.2
Transportation	5.4	9.9	10.3	10.9
Residential/Commercial	6.6	12.8	15.8	18.5
TOTAL	21.9	38.1	44.9	51.0

NONENERGY

Consumers in the nonenergy sector use oil, gas, and metallurgical coal as feedstock or raw material, instead of being used as fuel, in the manufacture of such products as petrochemicals, asphalt, lubricants, and steel. The demand growth rate in this sector will be less than historic rates due to slower economic growth, higher energy-derived raw material costs, and slower-than-historic demand growth for some petrochemical feedstocks. Eight percent of the total energy demand is represented in this sector.

INDUSTRIAL

This sector involves all mining and manufacturing industries. The growth rate in industrial energy demand will decline sharply from historic levels through 1980, due to rapid improvements in energy-use efficiency. Beyond 1980, demand growth will increase as efficiency improvement slows. This sector consumes gas, oil, coal, and electricity. Gas, although historically the predominant industrial fuel, will decline from 41% of sector demand in 1977 to about 24% by 1990, due to declining gas supply availability. Thirty-two percent of the total energy demand is represented in this sector.

TRANSPORTATION

Transportation is almost entirely dependent on oil and will account for about half of total oil consumed through 1990. Average annual transportation energy demand growth will be significantly slower than the historic rate, due primarily to increased mileage efficiency of new passenger cars. While total transportation demand grows through 1990, motor gasoline demand is projected to peak in 1980 at 7.3 million barrels per day, then decline to 6.5 million barrels per day by 1990. At the present time, almost three-quarters of transportation demand is for motor gasoline; remaining demand in this sector is for aviation fuel, diesel fuel, heavy fuel oil, and liquefied petroleum gas. Twenty-six percent of the total energy demand is represented in this sector.

RESIDENTIAL/COMMERCIAL

This sector involves private and public buildings, such as homes, stores, office buildings, hospitals, and schools. The sector's projected growth rate in energy demand will decline from that of the 1960--73 period. Significant factors in this decline are both reduced and more efficient energy use and the continuing trend from single-family houses to multiple housing units, which use less energy per unit. Demand growth will be met primarily by electricity and gas. Thirty-four percent of the total energy demand is represented in this sector.

SURVEYING ENERGY USAGE

UNIT I: ENERGY DEMAND

HANDOUT 2: HOUSEHOLD

The table below illustrates the various usage categories of household fuel consumption.

FUEL CONSUMPTION

Heating and Cooling	69.0%
Hot Water	10.5%
Cooking	6.9%
Refrigeration	6.9%
Lighting	1.7%
Miscellaneous	5.0%
	100.0%

The table following shows the direct energy consumption for a typical household. The consumption will vary with different living habits, climates, etc..

	ESTIMATED HOURS ANNUALLY	ESTIMATED KWH ANNUALLY
FOOD PREPARATION		
Blender	38.9	15
Broiler	69.6	100
Carving Knife	89.0	8

Coffee Maker	118.6	106
Deep Fryer	57.3	83
Dishwasher	302.2	363
Egg Cooker	27.1	14
Frying Pan	155.5	186
Hot Plate	71.6	90
Mixer	102.4	13
Oven, Microwave (only	131.0	190
Range		
with oven	96.3	1175
with self-cleaning oven	98.8	1205
Roaster	153.8	205
Sandwich Grill	28.4	33
Toaster	34.0	39
Trash Compactor	125.0	50
Waffle Iron	19.7	22
Waste Disposer	67.4	30
FOOD PRESERVATION		
Freezer (15 cu ft)	3504.4	1195
Freezer (frostless 15 cu ft)	3900.0	1761
Refrigerator (12 cu ft)	3020.7	728
Refrigerator (frostless 12 cu ft)	3791.3	1217
Refrigerator/Freezer (14 cu ft)	3487.7	1137
(Frostless 14 cu ft)	2974.0	1829
LAUNDRY		
Clothes Dryer	204.5	993
Iron (hand)	142.9	144

Washing Machine (automatic)	201.2	103
Washing Machine (non-automatic)	265.7	76
Water Heater (small wattage)	170.5	4219
Water Heater (large wattage)	107.5	4811
COMFORT CONDITIONING		
Air Cleaner	4320.0	216
Air Conditioner (room)	1000.0	860
Bed Covering	830.5	147
Dehumidifier	1466.9	377
Fan (attic)	786.5	291
Fan (circulating)	488.6	43
Fan (rollaway)	807.0	138
Fan (window)	850.0	170
Heater (portable)	133.1	176
Heating Pad	153.8	10
Humidifier	920.9	163
HEALTH & BEAUTY		
Germicidal Lamp	7050.0	141
Hair Dryer	36.7	14
Heat Lamp (infrared)	52.0	13
Shaver	128.1	1.8
Sun Lamp	57.3	16
Tooth Brush	71.4	0.5
Vibrator	50.0	2

HOME ENTERTAINMENT		
Radio	121.0	86
Radio/Record Player	1000.0	109
Television (black & white)		
tube type	2187.5	350
solid state	2181.8	120
Television (color)		
tube type	2200.0	660
solid state	2200.0	440
HOUSEWARES		
Clock	8500.0	17
Floor Polisher	49.2	15
Sewing Machine	146.7	11
Vacuum Cleaner	73.0	46

AUTOMOBILES

The use of the automobile is responsible for almost half of all the energy American individuals consume. Some adjustments must be made in the operation of automobiles or there will only be two alternatives for the future--our feet! Drivers can make a major contribution to solving this country's energy problems. It can be done in the best, fairest, and the most personally satisfying way possible--by setting an example. If it is not done now, automobile driving will be seriously limited in the near future.

MISCELLANEOUS

It requires energy to produce all consumer products from houses to cough drops. Consumer items such as sweaters and soap require energy at every step of processing. To calculate energy it is necessary to include raw materials, processing, freight, and merchandising.

Example Items	Energy/Year/Capita
Furniture	350 KWH
Cleaners and Soaps	380 KWH
Electric appliances	460 KWH
Paper tissues, Paper towels and etc.	250 KWH
Men's apparel	1560 KWH
Women's apparel	2040 KWH

United States material consumption per capita is about 30 tons, which includes nearly one-half ton of packaging material. The paper industry is one of the three largest consumers of energy and paper products require much energy to be produced. Aluminum scrap metal is selling for around $250 per ton and is in great demand. Recycling to save energy is resisted more today by primary producers than it was 25 years ago. Why?

MODULE #3

UTILITY BILLS AND ECONOMICS OF ENERGY CONSERVATION

MODULE DESCRIPTION:

This module presents a typical power utility rate schedule and some factors that have influenced its structure. A typical natural gas rate schedule is discussed and factors that influence the rate are touched upon.

The economics of some forms of energy conservation are discussed in terms of energy saved and the cost-effectiveness of the conservation measure implemented.

GOAL STATEMENT:

The objective of this module is to give the student an overview of the structure of the typical utility bill, to make the student aware of the fact that it will probably increase and that energy conservation is one way of economic relief.

MODULE #3

UTILITY BILLS AND ECONOMICS
OF ENERGY CONSERVATION

UNIT I: Utility Bills 3-2

Handout 1: Electricity 3-2

2: Natural Gas 3-4

A. Pricing 3-4

B. New Gas 3-5

C. Old Gas 3-5

D. Charge 3-6

UNIT II: Economics of Energy Conservation 3-7

Handout 1: Residential Buildings 3-7

A. Windows and Doors 3-7

B. Wall Construction and Insulation 3-8

C. Ceiling Insulation 3-8

D. Effectiveness of Energy Conservation Measures 3-9

E. Calculated Heat Loss Rates (example house) 3-10

UTILITY BILLS AND ECONOMICS OF ENERGY CONSERVATION

UNIT 1: UTILITY BILLS

UNIT OBJECTIVE

Upon completion of this unit the student will be able to discuss energy pricing, the development of power utility rate structure, and natural gas rate fluctuations.

SPECIFIC OBJECTIVES

Upon completion of this unit, the student will be able to:

1. Discuss the reasons for power utilities developing their present rate schedules.
2. Explain why the utility rate schedules are not energy-conservation oriented.
3. Discuss the forces being applied to make utility bills increase.
4. Determine the cost-effectiveness of certain energy conservation measures.

UTILITY BILLS AND ECONOMICS OF ENERGY CONSERVATION

UNIT I: UTILITY BILLS

HANDOUT 1: ELECTRICITY

The maximum profit margin for electric utilities is controlled by law, and the profit is based on the amount of capitalization of the company. Therefore, it pays the company to build new facilities. To justify these new facilities, it is necessary to point to increasing consumption. Thus, it pays the utilities to increase consumption because this increases the sale of their product and because an increasing rate of consumption enables them to justify building new plants.

An indication of the success of advertising is seen in the seasonal peak load. A few years ago, even in the south, the peak electrical demand occurred in winter with increased heating and lighting requirements. Then the utilities decided to level out the peak by encouraging the use of air conditioning. This campaign was so successful that, presently, the peak demand in almost all areas in the United States is in the summer instead of the winter, and air conditioning is one of the most rapidly growing uses of electricity.

Another aspect to electric consumption having a large effect on energy conservation is the rate structure. Presently,

the pricing of electricity is such that small users pay a higher rate than larger users. Thus, small consumers subsidize larger ones. If the rate structure was to be altered so that larger consumers paid at the same or even higher rates for electricity, there would be a greater incentive for conservation.

A typical rate schedule of a power utility company follows. Usually there is a $2.00 minimum for the first 30 KWH or less and the rates then decrease, as shown:

	CHARGE/KWH
Next 20 KWH	5 cents
Next 150 KWH	4 cents
Next 200 KWH	3 cents
Next 400 KWH	2 cents
In excess of 800 KWH	1.5 cents

As most of the large consumers are in industry, this could have a large economic impact and would probably have to be implemented slowly. However, industry is very responsive to economic considerations and probably has the capability of changing practices fairly rapidly. Currently, on the average, energy accounts for only 1.5% of production costs in industry so that a significant price increase could probably be handled without being too serious an economic impact.

UTILITY BILLS AND ECONOMICS
OF ENERGY CONSERVATION

UNIT I: UTILITY BILLS

HANDOUT 2: NATURAL GAS

PRICING

Big Oil's control on natural gas, which provides about 35 percent of the nation's energy requirements, covers both production and supplies. Every major producer of natural gas is also a producer of crude oil and in 1970, the top 14 in natural gas were also among the top 15 oil producers.

Producers are withholding supplies in anticipation of either higher prices being allowed by the FPC or outright deregulation. In August 1974, information given to the Senate by the Department of the Interior showed that 91 percent of oil and gas leases it had let were nonproducing. In other words, gas from 94,224 leases out of 105,502 is being withheld.

FPC commissioners began promising and delivering higher prices in 1969. Presently, they are promising deregulation and have been joined by the Administration. The immediate effect is additional gas withholding. Few companies are going to supply natural gas at 50 cents per thousand cubic feet, when there is the possibility that by waiting, they may get triple that price.

Deregulation would remove all FPC price controls which could triple or quadruple natural gas prices. The first year of deregulation would cost consumers between $9.2 and $11.2 billion in higher prices and add proportionately to oil company profits. Natural gas deregulation alone would be enough to bankrupt many household budgets that scarcely withstood the two rate increases granted last year on top of all the other increases in consumer prices.

Some first sale prices of natural gas are listed below. These prices are maximum lawful prices in January of 1979 (Natural Gas Policy Act of 1978).

New Gas--certain gas not committed or dedicated to interstate commerce on November 8, 1978.

Old Gas--certain gas committed or dedicated to interstate commerce on November 8, 1978.

NEW GAS	$/mmBTU
High Cost--Off Shore	2.096
High Cost--Below 15,000 feet	2.096
New Natural Gas--On Shore	1.98
High Cost--Stripper	2.243
Not Covered	1.639

OLD GAS	$/mmBTU
Post--1974 Gas	1.639
Rollover Contract Gas	.607
Flowing Gas	.334

Pricing becomes complicated when an equity mix is added to old gas pricing and new gas pricing. Plus, there is a monthly inflation factor to be added.

A second sale price of natural gas would be made by the utility company in most cases. Rates charged to utility customers are usually higher in winter because more new wells are involved to supply the need. Rates are lower in the summer months because older wells can supply the need.

A typical rate schedule of a gas utility company follows. Usually there is a $4.50 minimum for the first 1000 cubic feet or less and the rates then decrease, as shown:

	CHARGE/1000 Cu Ft
Next 29,000 Cu Ft	$ 2.36
Next 40,000 Cu Ft	2.31
In excess of 70,000 Cu Ft	2.26

UTILITY BILLS AND ECONOMICS
OF ENERGY CONSERVATION

UNIT II: ECONOMICS OF ENERGY CONSERVATION

HANDOUT 1: RESIDENTIAL BUILDINGS

Climbing energy prices promote a strong incentive to reduce energy consumption. One way to conserve energy in buildings is to lower heat losses. This can be done by providing more insulation in walls and ceilings of new buildings, reducing window area, and using double pane windows and storm doors. Though these energy conservation measures are obvious, there are physical and economic limits beyond which energy conservation measures are not effective. This unit relates to the cost effectiveness of practical energy conservation measures in residential buildings that provide economic returns on invested capital.

WINDOWS AND DOORS

The average window area for houses is about 15% of the floor area. By reducing this to 10% there will be reduction in both heat loss rate and the initial glass cost. Heat losses can be reduced by as much as 3000 BTUH with double pane windows. Reduction in window area can be achieved by raising the sill height without sacrificing the view or lighting. As much as 25 to 30 percent of the heat loss from the

house occurs through doors and windows. The use of storm doors and windows will reduce this loss by 50 percent.

WALL CONSTRUCTION AND INSULATION

Walls constructed with 2 x 4 studs on 16 inch centers have space for 3 1/2 inches of R-11 insulation. By framing the wall with 2 x 6 studs on 24" centers, insulation can be increased to R-19 with 40 percent reduction in heat loss rate. New types of sheathing are available with an insulation value of R-5. Older homes, with no wall insulation, can have mineral wool or similar material blown in to achieve an insulating value of about R-7.

Basement walls that extend above ground can be insulated on the interior surface by adding furring strips and insulation which can be covered with gypsum board or plywood. In moderate climates, 2 x 2 furring strips with R-7 insulation is effective. In very cold climates, 2 x 4 furring strips with R-11 insulation may be considered.

CEILING INSULATION

Ceiling insulation to R-30 can easily be attained and is recommended. The minimum insulation should be to R-19.

EFFECTIVENESS OF ENERGY CONSERVATION MEASURES

Consider a moderate-sized two-story house located in a region where the winter degree-days is 6000 and the design ambient temperature is -10°F.

The example house has the following data:

Ceiling Area			1621 ft^2
Wall Area			2335 ft^2
Window Area	North	45	
	West	50.5	
	South	100.0	
	East	0	
	Total		195.5 ft^2
Door Area			98 ft^2
Roof Area			1793 ft^2

The following three pages give the calculated heat loss rates for the "example house". The basic design is identified by "line 13" on the first page, and the calculated heat load is 62,500 BTUH for the design condition.

WALL INSULATION	CEILING INSULATION	DOORS	WINDOWS	BTUH HEAT LOSS
R-0	R-7	Solidwood 1.5 in.	Single glass 100% glass	88,846
R-0	R-7	Solidwood 1.5 in.	Single glass 80% glass	87,234
R-0	R-7	Solidwood 2.0 in.	Single glass 80% glass	87,073
R-0	R-7	Storm metal & 1.5 in. Solidwood	Single glass 80% glass	86,989
R-0	R-7	Solidwood 1.5 in.	Double insulating Double glass 80% 3/16 in. air space	82,077
R-0	R-7	Solidwood 2.0 in.	Double insulating Double glass 80% 3/16 in. air space	81,916
R-0	R-7	Storm metal & 1.5 in. Solidwood	Double glass 80% Double insulating 3/16 in. air space	81,832
R-0	R-7	Solidwood 1.5 in.	Triple insulating Triple glass 80% 1/2 in. air space	77,605
R-0	R-7	Storm metal & 2.0 in. Solidwood	Triple insulation Triple glass 80% 1/2 in. air space	77,229
R-7	R-7	Solidwood 1.5 in.	Single glass 100% glass	66,636
R-7	R-7	Solidwood 1.5 in.	Double insulating Double glass 80% 3/16 in. air space	59,867
R-7	R-7	Storm metal & 1.5 in. Solidwood	Triple insulating Triple glass 80% 1/2 in. air space	55,149
R-7 "Line 13"	R-11	Solidwood 1.5 in.	Single glass 80% glass	62,500
R-7	R-11	Storm metal & 1.5 in. Solidwood	Single glass 80% glass	62,255

WALL INSULATION	CEILING INSULATION	DOORS	WINDOWS	BTUH HEAT LOSS
R-7 "Line 15"	R-11	Solidwood 1.5 in.	Double insulation Double glass 80% 3/16 in. air space	57,343
R-7	R-11	Storm metal & 1.5 in. Solidwood	Double insulating Double glass 80% 3/16 in. air space	57,102
R-7	R-11	Storm metal & 2.0 in. Solidwood	Triple insulating Triple glass 80% 1/2 in. air space	52,496
R-11	R-11	Solidwood 1.5 in.	Single glass Double glass 80% 3/16 in. air space	58,987
R-11	R-11	Storm metal & 1.5 in. Solidwood	Double insulating Double glass 80% 3/16 in. air space	53,585
R-11	R-11	Storm metal & 2.0 in. Solidwood	Double insulating Single glass 80% Emissivity = 0.2 1/2 in. air space	49,525
R-11	R-11	Storm metal & 2.0 in. Solidwood	Triple insulating Triple glass 80% 1/2 in. air space	48,983
R-11	R-19	Solidwood 1.5 in.	Single glass 100% glass	58,233
R-11 "Line 23"	R-19	Solidwood 1.5 in.	Single glass 80% glass	56,621
R-11	R-19	Solidwood 1.5 in.	Double insulating Double glass 80% 3/16 in. air space	51,464
R-11	R-19	Solidwood 1.5 in.	Double insulating Single glass 80% Emissivity = 0.2 1/2 in. air space	47,534
R-11	R-19	Storm metal & 1.5 in. Solidwood	Double insulating Single glass 80% Emissivity 80% 1/2 in. air space	47,288
R-11	R-19	Storm metal & 2.0 in. Solidwood	Triple insulating Triple glass 80% 3/16 in. air space	46,616

WALL INSULATION	CEILING INSULATION	DOORS	WINDOWS	BTUH HEAT LOSS
R-0	R-11	Wooden Door 1.5 in.	Single glass 100% glass	86,303
R-0	R-19	Wooden Door 1.5 in.	Single glass 100% glass	83,915
R-7	R-0	Wooden Door 1.5 in.	Single glass 100% glass	84,698
R-7	R-11	Wooden Door 1.5 in.	Single glass 100% glass	64,112
R-7	R-19	Wooden Door 1.5 in.	Single glass 100% glass	61,743
R-11	R-0	Wooden Door 1.5 in.	Single glass 100% glass	81,165
R-11	R-7	Wooden Door 1.5 in.	Single glass 100% glass	63,120
R-11	R-11	Wooden Door 1.5 in.	Single glass 100% glass	60,599
R-19	R-0	Wooden Door 1.5 in.	Single glass 100% glass	77,748
R-19	R-7	Wooden Door 1.5 in.	Single glass 100% glass	59,720
R-19	R-11	Wooden Door 1.5 in.	Single glass 100% glass	57,202
R-19	R-19	Wooden Door 1.5 in.	Single glass 100% glass	54,838
R-0	R-0	Wooden Door 1.5 in.	Single glass 100% glass	107,032
R-19	R-40	Wood Storm Doors & 2.0 in. Solidwood Doors	Triple insulating 1/2 in. air space & Storm windows 60% glass-wood sash	40,07?

Total Window Area = 195.42 Sq. Ft.
Total Door Area = 98 Sq. Ft.
45° Pitched Roof
No Basement

REDUCTION IN HEAT LOSS RATES

When a double-glazed window replaces the single-glass window "Line 15" in the example house, the heat loss rate reduces from 62,500 BTUH to 57,343 BTUH, which is a reduction of 5,160 BTUH. With double glazing and increased ceiling insulation the heat loss rate reduces further to 51, 460 BTUH for a total reduction of 11,040 BTUH from the original condition. Other energy conserving features can be compared from the tabulated values. The cost-effectiveness of the energy conservation measure is dependent upon energy cost, rate of energy cost increase, interest and terms of the loan for money borrowed to implement the energy conserving measure, property tax if any, increase in annual insurance premium and savings on income taxes.

ENERGY CONSERVATION COST AND SAVINGS

The methodology for determining the cost and benefits from investments made in energy conservation practices is presented. Using the example building, suppose that the ceiling insulation thickness is increased from 3 1/2 inches to 6 inches, changing the R factor from R-11 to R-19, and the wall insulation is increased from R-7 to R-11. This results in reduction of heat loss rate from 62,500 BTUH "Line 13" to 56,621 BTUH "Line 23" or 5879 BTUH.

The reduction in heat loss rate will mean a reduction in

consumption of energy. The amount of energy saving is determined as follows: The design heating temperature difference is:

$$TD = 68^{\circ}F - (-10^{\circ}F) = 78^{\circ}F$$

The design heat load for the base design is 62,500 BTU per hour. The heat requirement for degree-day is:

$$\frac{62,500}{78} \times 24 = 19,300 \text{ BTU/DD}$$

The reduction in heat loss rate because of the added insulation is (62,500 - 56,621) x 24/78 = 5879 x 24/78 = 1809 BTU per DD. For a heating season with 6240 DD, the savings in energy is:

$$1809 \times 6240 = 11.3 \text{ mBTU}$$

With electric resistance heating at 4¢/KWH, the heating cost is $11.72 mBTU. The annual dollar savings is:

$$\frac{\$11.72}{\text{mBTU}} \times 11.3 \text{ mBTU} = \$132.44$$

The total cost of insulation to effect a savings of $132 annually in heat costs is determined as follows: The extra ceiling insulation of 3 inches is about $0.10/ft^2 including installation, or 0.10 x 1621 = $162, and for the walls the added costs are about $0.06/ft^2, or 0.06 x 2336 = $140. The total added cost for insulation is about $302.

Although in this example it is readily seen that with $132 annual energy cost savings, the added $302 cost for insulation is returned through fuel savings in less than three years, we will continue through with this example to illustrate the economic analysis. Let us assume that the money for insulating was borrowed at ten percent interest and 15-year loan. The annual repayment factor is 0.13, so that the mortgage payment on the loan is:

$$\text{Annual Mortgage Payment} = 0.13 \times 302 = 39/\text{yr}$$

In addition to the mortgage, there are property tax and insurance to be paid at an annual rate of, say, 1.5 percent of the added cost or, 0.015 x 302 = $4.50/year, and there are savings on income taxes for interest paid. Although the credit will decline annually and is dependent upon the income level of the homeowner, assume that the savings on income taxes balance the amount for property tax and insurance.

The ratio of annual savings to annual cost is then:

$$\text{Savings Factor (SF)} = \frac{\$132}{\$\ 39} = 3.4$$

If the energy cost increases, the savings factor will increase.

While in this example the ratio of the benefit in annual savings to cost of the added insulation is large, there are some energy conservation measures where the benefit/cost ratio may be less than one. Obviously such energy conservation measures should not be implemented.

MODULE #4

HOW TO SEARCH FOR ENERGY CONSERVATION OPPORTUNITIES

MODULE DESCRIPTION:

This module discusses some of the many opportunities for the individual and the community to save and to conserve energy. The energy consumption of the automobile, of the home and of the appliances is discussed in terms of conserving energy.

Community involvement in energy conservation is also surveyed.

GOAL STATEMENT:

The objective of this module is to give the individual a comprehension of the amount of energy waste in America and of the many opportunities to rectify this shameful situation.

MODULE #4

HOW TO SEARCH FOR ENERGY CONSERVATION OPPORTUNITIES

UNIT I: Individual Conservation 4-3

Handout 1: Introduction 4-3

2: Tips for Auto Energy Savers 4-6

3: Energy Saving Tips in Heating 4-15

4: Tips for Cooling Energy Savers 4-21

5: See "Module 5".

6: See "Module 6".

7: See "Module 7".

UNIT II: Community Conservation 4-26

Handout 1: Community Involvement 4-26

A. General 4-26

B. Specific 4-26

HOW TO SEARCH FOR ENERGY CONSERVATION OPPORTUNITIES

UNIT I: INDIVIDUAL CONSERVATION

UNIT OBJECTIVE

Upon completion of this unit the student will be able to discuss relative amounts of personal energy consumed and the many ways available to reduce individual energy consumption.

SPECIFIC OBJECTIVES

Upon completion of this unit, the student will be able to:

1. Discuss the energy usage of automobiles and the opportunities for conservation.
2. Understand the conservation of energy related to hot water heating, space heating, and space cooling.
3. Discuss ways to save energy in the use of appliances.
4. Be knowledgeable in lighting conservation techniques.

HOW TO SEARCH FOR ENERGY CONSERVATION OPPORTUNITIES

UNIT I: INDIVIDUAL CONSERVATION

HANDOUT 1: INTRODUCTION

Most Americans are highly mobile and consumption oriented. In the daily routine, energy is consumed at ever higher rates. Our present consumption patterns, as well as where we live and how we work, greatly influence our demand for energy; and it is equally true that availability of relatively cheap energy has influenced where we live, the work we do and how our leisure time is spent. We depend upon fossil fuels for home-heating, cooking, hot water, electricity, air conditioning, gadgetry, radio and television, light and advertising.

No product has so governed our lives as the energy-extravagant automobile, transforming our landscape and creating suburbia. It has drastically altered our concept of the city, our architecture and the way we relate to each other. It has allowed us to have unparalleled freedom of movement, a sense of status, economic success, prowess and a distinct lifestyle. In the workplace, increased productivity has been possible through increased consumption of energy. The worker, the workplace, the work ethic and organized labor are deeply affected by the abundance of cheap energy.

Is there any solution to energy problems that will not affect our use of the automobile and other modes of transportation? Or are we locked into the automobile? How could we get out of it? Do we want to? Do we have a choice? What are the choices? And why do other nations, even more acutely affected by energy costs and supplies, seek to emulate our use of the automobile? What do energy shortages and higher energy costs mean to the worker and the way we work? How significant are phrases such as "planned obsolescence" and "a throw-away society"? Can employers and employees adapt to changes which the energy problem imposes? Just how much of our ways of life and work are at stake?

Another aspect of our energy problem is the environment. This part of the crisis is also generated by a culture bent on wastefulness.

Improving the standard of living is a necessary and vital part of evolution. However, in the process of improvement unnatural contingencies are generated that tend to destroy the very environment which sustains life, then this form of development must be questioned.

Solutions to the energy problems are certain to alter life-styles as the price of energy increases and new sources of energy become available. Cheap energy has spoiled most Americans in the realm of energy conservation, however, our ever true patriots will meet the challenge of the energy dilemma.

The following table gives the percentages for Personal Energy Usage:

Automobiles	42%
Heating and Air Conditioning	40%
Hot Water	6%
Refrigeration	4%
Cooking	4%
Lighting	1%
Miscellaneous	3%

The magnitude of the opportunity to save energy is directly related to the magnitude of energy used by the user.

HOW TO SEARCH FOR ENERGY CONSERVATION OPPORTUNITIES

UNIT I: INDIVIDUAL CONSERVATION

HANDOUT 2: TIPS FOR AUTO ENERGY SAVERS

There are more than 100 million registered automobiles in the United States. A typical car, with an average fuel economy of less than 15 miles per gallon, travels about 10,000 miles each year and uses well over 650 gallons of gasoline.

Altogether, our private automobiles consume some 70 billion gallons of gasoline each year. That is about 4.5 million barrels a day or about two-thirds of the amount of petroleum currently being imported into the United States.

The importance of individual gasoline savings cannot be over-emphasized. If, for example, the fuel used by the average car were reduced just 15 percent through fewer daily trips, better driving practices, and better maintenance, the Nation's use of petroleum would fall by nearly two-thirds of a million barrels per day, or about 3.5 percent of demand.

We all can improve on our conservation efforts on the road. Here are some of the ways:

1. Use public transportation, a motorcycle, a moped, a bicycle, or walk to work.
2. Share your ride. Join a carpool or a vanpool.

About one-third of all private automobile mileage is for commuting to and from work.

3. Go shopping with a neighbor occasionally. If the average occupancy (currently 1.3 people per commuter car) were increased by just 1 person, each commuter would reduce his costs, energy consumption, and driving stress. And the nationwide gasoline savings --which would reduce bur reliance on more expensive imports--would be more than 600,000 barrels per day.
4. Plan your route. Instead of jumping in the car and taking off, make sure to know all the places you plan to go. Organize stops to avoid retracing paths. If there are many stops to be made within an area, park in a central location and walk.
5. Eliminate unnecessary trips. Can you find one driving trip per week that could be handled by telephone or combined with another trip? If every automobile took just one less 10-mile trip a week, the Nation would save 3 1/2 billion gallons of gas a year, or nearly 5 percent of the total passenger car demand for gas.
6. Schedule trips to avoid rush hours. This saves time, energy, and frustration.
7. Choose routes with the less number of traffic lights and stop signs.

8. Do not figure your efficiency in miles per tankfull. This leads car manufacturers to produce larger gas tanks. It takes energy to haul all of the extra gasoline.

The driving technique of the person behind the wheel is the most important single element in determining the fuel economy of any car. A careful driver may get 20 percent more miles per gallon than the average driver and 50 percent more than a wasteful one. Some of the careful driving techniques follow:

1. Observe the 55 mph speed limit on the highway. Most automobiles get about 20 percent more miles per gallon on the highway at 55 mph than they do at 70 mph.
2. Accelerate smoothly and moderately. Achieve your desired speed quickly, and then keep a steady pressure on the accelerator, just enough to maintain speed. Plan ahead to avoid excessive acceleration in passing cars at highway speeds. Save the passing gear for real emergencies.
3. Drive at a steady pace. Avoid stop-and-go traffic. Frequently check the traffic situation well ahead of you. Adjust your driving to avoid unnecessary, wasteful accelerations and decelerations.
4. Minimize braking. Anticipate speed changes. Take your foot off the accelerator as soon as you see a

red light or slowed traffic ahead.

5. Do not let the motor idle for more than a minute. Turn off the engine. It takes less gasoline to restart the car than it takes to let it idle. Generally there is no need to press the accelerator down to restart the engine.
6. Do not rev the engine before turning off the key. This damages the engine and wastes gasoline.
7. Do not overfill your tank. Remove the nozzle or ask the gas station attendant to remove it when the automatic valve closes. This will eliminate any chance of spillage.
8. Plan your trips carefully. Select routes that will allow you to consolidate errands and avoid congested areas.
9. Use your head before you drive. Plan your trips. Try to use these tips as you drive. Record your gasoline use, and try to get more miles per gallon out of your car.
10. Park the car in the shade on summer days so your air conditioner will have to work less when you return.

Good car maintenance and a wise selection of accessories can mean fuel economy and dollars saved.

1. Have your car tuned as recommended by the manufacturer--usually twice a year, spring and fall. Regular tune-ups extend engine life and improve performance. A poorly tuned car could use as much as 3 to 9 percent more gasoline than a well-tuned one. The tune-up will pay for itself in gasoline savings and car reliability.
2. Check for leaks at the carburetor, fuel pump, fuel line and tank.
3. Keep the engine filters clean. Clogged filters waste gasoline.
4. Use the lowest gasoline octane rating for your car (consult owners manual) which will give proper performance. Lower octane grades can save you money.
5. Use proper oil grade recommended for your car. Too thin a grade can cause damage and too thick a grade of oil requires your car to use more power and that means more gasoline. If you change the oil yourself, take the used oil to your service station for recycling.
6. Check tire pressures regularly--once a month. Underinflated tires increase gas use. You can lose about 2 percent in fuel economy for every pound of pressure under the recommended pounds per-square-inch.

7. Check to see that the tires are properly balanced and wheels properly aligned. If they are not, they can create drag, forcing the engine to use more power--thus more energy. A bent frame can have the same effect.
8. Consider radial tires. They can mean from 3 to 5 percent improvement in gas mileage in the city, 7 percent on the highway, and 10 percent at 55 mph after the tires are warmed up for 20 minutes. And they last longer, too. Never mix radials with conventional tires.
9. Remove unnecessary weight from the car. The lighter the car, the less gas it uses. An extra 100 pounds decreases fuel economy about 1 percent for the average car, and 1 1/4 percent for small cars.
10. Keep the radiator clean. Removing bugs and foreign matter from radiators and air conditioners can prevent overheating and loss of energy.

Study the market before you buy. Ask your dealer, or write to Fuel Economy, Pueblo, Colorado 81009, for a free copy of the latest "EPA/FEA Gas Mileage Guide". Study the fuel economy figures and tables that compare specifications. Review mileage test results publicized by Consumers Union and motor industry magazines. Generally the best fuel economy

is associated with low vehicle weight, small engines, manual transmissions, low axle ratio, and low frontal area (width of the car times its height). Consider before you buy:

1. Buy the most energy-efficient car of the size and style you want. Do not let the car price alone determine your choice. Make your decision on the basis of the combination of purchase price and the estimated fuel costs.
2. A light exterior car color combined with light interior upholstery will reduce heat absorption and keep the air conditioner from working so hard.
3. Tinted glass helps reduce the need for an air conditioner.
4. Fuel injection distributes the fuel more uniformly and efficiently than do carburetors, thus saving energy.
5. An electronic ignition system is a fuel saver. Its improved spark means better combustion and less chance for fuel-robbing sparkplug fouling.
6. Choose accessories wisely. Purchase only the optional equipment and accessories really needed. Items like air conditioning, automatic transmission, and power steering require considerable energy, all of which is derived from burning gasoline. Other equipment,

such as power brakes, electric motor-driven windows, seats and radio antennas, require less energy for their operation, but all accessories add to the vehicle weight--and this reduces fuel economy. Overdrive options and cruise control can save up to 15% on fuel at highway speeds. These are good choices on a new car.

7. Do not buy an air conditioner unless you really need it. Even when you are not using it, it adds to the weight of the car.
8. If you have a car air conditioner or other power-draining accessories, use them sparingly. The cooling equipment reduces fuel economy from 10 percent on the highway up to almost 20 percent in stop-and-go traffic.

Other ways an individual can conserve are:

1. Vacation at home this year. Discover nearby attractions.
2. Choose a hotel or campground close to where you live. A nearby hotel or campground often can provide as complete and happy a change from routine as one that is hundreds of miles away.
3. Plan to stay in one place if you vacation away from home. "Hopping around" takes transportation energy.

4. Take a train or a bus instead of the family car. Save gasoline and relax.
5. Rediscover the pleasures of walking, hiking, and bicycling during your vacation. They are the most energy-conserving means of transportation and the healthiest for most people.
6. Save energy at home if you are going away. Remember to turn off lights, lower heating temperatures in winter, and turn off air conditioning in summer.

HOW TO SEARCH FOR ENERGY CONSERVATION OPPORTUNITIES

UNIT I: INDIVIDUAL CONSERVATION

HANDOUT 3: ENERGY SAVING TIPS IN HEATING

The U.S. Department of Energy has outlined tips for saving energy in heating. This list serves as a summary of conservation measures available to the homeowner when considering heating the home.

Heating and cooling our homes account for most of our residential energy costs. Do not waste any of that precious conditioned air, whether you pay for it yourself or pay your landlord for it.

During Both Heating And Cooling Seasons

1. Close off unoccupied rooms and shut their heat or air conditioning vents; or turn off room air conditioners. (This does not apply if you have a heat pump system. Leave it alone; shutting vents could harm a heat pump.)
2. Use kitchen, bath, and other ventilating fans sparingly. In just one hour these fans can blow away a houseful of warmed or cooled air. Turn them off just as soon as they have done their job.

3. Keep your fireplace damper closed unless you have a fire going. An open damper in a 48 inch square fireplace can let up to 8 percent of your heat out the chimney.

Heating Energy Savers: do not turn the heat on until you have to. On cool evenings use your fireplace instead and add a blanket at night.

With Heating Equipment

1. If you use electric furnace heating, consider a heat pump system. The heat pump uses thermal energy from outside air for both heating and cooling. Costs for these pumps run from about $2,000 for a whole house unit to about $425 for room size. But they can cut your use of electricity for heating by 30 to 40 percent and also can provide some savings in cooling costs.
2. If you plan to buy a new gas heating system, ask your gas utility or public service commission about the savings potential of electronic ignition. Ask also about possibilities for retrofitting the system you may already own.
3. Consider the advantage of a clock thermostat for your heating system. The clock thermostat will turn the heat down for you automatically at a regular hour before you retire and turn it up again before

you wake. While you can easily turn your thermostat back at night and up again in the morning yourself, the convenience of a clock thermostat may be worth the $70 to $90 cost to you.

4. Consider buying a properly sized furnace that incorporates an automatic flue damper. This device reduces the loss of heat when the furnace is off. (Contact your gas utility or oil supplier for guidance.)

5. Do not use your fireplace for supplemental heating when your furnace is on unless you take one of the measures suggested below to lessen the loss of heated air from the house.

The warmth from a fire on the hearth generally does not radiate through the house; the heat gain is confined to the room with the fireplace. And when your furnace is on, too, a considerable amount of heated air from the rest of the house flows into the fireplace and goes wastefully up the chimney. Then the temperature in other rooms of the house goes down, and the furnace uses more fuel to raise it to the level controlled by the thermostat. So you use more fuel, rather than less, when the furnace and fireplace are both going.

Lessen Heat Loss When You Use Fireplace When Furnace Is On

1. Lower the thermostat setting to 50 to 55 degrees. Some warmed air will still be lost, but the furnace

will not have to use as much fuel to heat the rest of the house to these temperatures as it would to raise the heat to 65 degrees.

2. Close all doors and warm air ducts entering the room with the fireplace and open a window near the fireplace about 1/2 to 1 inch. Air needed by the fire will be provided through the open window and the amount of heated air drawn from the rest of the house will be reduced.
3. If you have a simple open masonry fireplace, consider installing a glass screen. This will cut down on the loss of warmed air through the flue.

When The Heat Is On

1. Lower your thermostat to 65 degrees during the day and 55 degrees at night. You can save about 3 percent on your fuel costs for every degree you reduce the average temperature in your home. In addition, you can save about 1 percent on your heating bills for every degree you dial down only at night.
2. Keep windows near your thermostat tightly closed, otherwise it will keep your furnace working after the rest of the room has reached a comfortable temperature.
3. Have your oil furnace serviced at least once a year,

10. Dust or vacuum radiator surfaces frequently. Dust and grime impede the flow of heat. And if the radiators need painting, use flat paint, preferably black. It radiates heat better than glossy.
11. Keep draperies and shades open in sunny windows; close them at night.
12. For comfort in cooler indoor temperatures, use the best insulation of all--warm clothing.

Dressing Wisely Can Help You Retain Natural Heat

1. Wear closely woven fabrics. They add at least a half degree in warmth.
2. For women, slacks are at least a degree warmer than skirts.
3. For men and women, a light, long-sleeved sweater equals almost 2 degrees in added warmth; a heavy long-sleeved sweater adds about 3.7 degrees; and two lightweight sweaters add about 5 degrees in warmth because the air between them serves as insulation to keep in more body heat.

If every household in the United States lowered its average heating temperatures 6 degrees over a 24 hour period, we would save more than 570,000 barrels of oil per day or more than 3.5 percent of our current oil imports.

HOW TO SEARCH FOR ENERGY CONSERVATION OPPORTUNITIES

UNIT I: INDIVIDUAL CONSERVATION

HANDOUT 4: TIPS FOR COOLING ENERGY SAVERS

The following tips for cooling energy savers are from the U.S. Department of Energy and serve as a convenient summary for the points discussed in this unit.

1. Over cooling is expensive and wastes energy. Do not use or buy more cooling equipment capacity than you actually need.
2. If you need central air conditioning, select the smallest and least powerful system that will cool your home adequately. A larger unit than you need only costs more to run but probably will not remove enough moisture from the air.
3. Ask your dealer to help you determine how much cooling power you need for the space you have to cool and for the climate in which you live. (For further information, see copies of Energy Efficiency Ratios.)
4. Make sure the ducts in your air conditioning system are properly insulated, especially those that pass through the attic or other uncooled spaces. This could save you almost 9 percent in cooling costs.

5. If you do not need central air conditioning, consider using individual window or through-the-wall units in rooms that need cooling from time to time. Select the smallest and least powerful units for the rooms you need to cool. As a rule, these will cost less to buy and less to operate.
6. Install a whole-house ventilating fan in your attic or in an upstairs window to cool the house when it is cool outside, even if you have central air conditioning.
7. It will pay to use the fan rather than air conditioning when the outside temperature is below 82 degrees. When windows in the house are open, the fan pulls cool air through the house and exhausts warm air through the attic.

When You Use Air Conditioning

1. Set your thermostat at 78 degrees, a reasonably comfortable and energy-efficient indoor temperature.
2. The higher the setting and the less difference between indoor and outdoor temperature, the less outdoor hot air will flow into the building.
3. If the 78°F setting raises your home temperature 6 degrees (from 72°F to 78°F, for example), you should save between 12 and 47 percent in cooling

costs, depending on where you live.

4. Do not set your thermostat at a colder setting than normal when you turn your air conditioner on. It will not cool faster, it will cool to a lower temperature than you need and use more energy.
5. Set the fan speed on high except in very humid weather. When it is humid, set the fan at low--you will get less cooling but more moisture will be removed from the air.
6. Clean or replace air conditioning filters at least once a month. When the filter is dirty, the fan has to run longer to more the same amount of air and this takes more electricity.
7. Turn off your window air conditioners when you leave a room for several hours. You will use less energy cooling the room down later than if you had left the unit running.
8. Consider using a fan with your window air conditioner to spread the cooled air farther without greatly increasing your power in use. But be sure the air conditioner is strong enough to help cool the additional space.
9. Do not place lamps or TV sets near your air conditioning thermostat. Heat from these appliances is

sensed by the thermostat and could cause the air conditioner to run longer than necessary.

With Or Without Air Conditioning

1. Keep out daytime sun with vertical louvers or awnings on the outside of your windows, or draw draperies, blinds, and shades indoors. You can reduce heat gain from the sun by as much as 80 percent this easy way.
2. Keep lights low or off. Electric lights generate heat and add to the load on your air conditioner.
3. Do your cooking and use other heat-generating appliances in the early morning and late evening hours whenever possible.
4. Open the windows instead of using your air conditioner or electric fan on cooler days and during cooler hours.
5. Turn off the furnace pilot light in summer, but be sure it is re-ignited before you turn the furnace on again.
6. Dress for the warmer indoor temperatures. Neat but casual clothes of lightweight openweave fabrics are most comfortable.
7. A woman will feel cooler in a lightweight skirt instead of slacks. A man will feel cooler in a

short-sleeved shirt than in a long-sleeved shirt of the same weight fabric.

Without Air Conditioning

1. Be sure to keep windows and outside doors closed during the hottest hours of the day.
2. Use windows or whole-house ventilation fans to cool the house when it is cool outside.
3. Use vents and exhaust fans to pull heat and moisture from the attic, kitchen and laundry directly to the outside.

If everyone raised air conditioning temperature 6 degrees, we would save the equivalent of 36 billion kilowatt-hours of electricity used in the nation in 1 year.

HOW TO SEARCH FOR ENERGY CONSERVATION OPPORTUNITIES

UNIT II: COMMUNITY CONSERVATION

HANDOUT 1: COMMUNITY INVOLVEMENT

Conservation practices must extend beyond the range of the individual if there is to be a viable conservation policy. Some possible community action ideas follow:

GENERAL

1. Alert individuals and assist those who want to know how or where they can conserve.
2. Exert citizen pressure to prohibit wasteful practices.
3. Support local or regional regulations that improve the environment.

SPECIFIC

1. Discourage overheating or overcooling of public buildings, buses, restaurants, theaters and etc..
2. Help to outlaw such energy-wasteful luxuries as electrically heated sidewalks.
3. Promote the building of bike lanes, bike parking, and bike protection (present laws favor autos).

4. Encourage staggered work hours to reduce rush-hour traffic jams. This could help to eliminate the Nation's so-called five o'clock "highway parking lot".
5. Reward energy conservers. For example, develop graduated toll rates for automobiles based on the number of passengers it is transporting. Reward the car containing a specific number of persons (four or five) by permitting it to travel at the lowest toll rate or perhaps even allow it to go toll free.
6. Promote public transportation.
7. Create more safe areas to ride bicycles and to walk.
8. Assist in the development of methods to utilize the energy of community waste.
9. Reverse the power company's electric rate schedule to benefit the conserver rather than the extravagant user and squanderer.
10. Ban the advertising of utility companies.
11. Remove favorable freight rates for virgin materials to give more incentive to recycling.
12. Remove depletion allowances to give more incentive to recycling.

There are many inequities created by the government for special groups that squander our resources and prevent recycling or conservation.

MODULE #5

LIGHTING CONSERVATION OPPORTUNITIES

MODULE DESCRIPTION:

This module discusses some of the necessary aspects of good lighting such as; appropriate illumination, types of fixtures, and security lighting.

Lighting energy-conservation is presented in terms of ease to accomplish, the formation of good habits, prevention of heat buildup, and flexible lighting systems.

GOAL STATEMENT:

The objective of this module is to create an awareness in the student, of the energy used for overlighting and to the ease of implementing conservation measures in this category.

MODULE #5

LIGHTING CONSERVATION OPPORTUNITIES

UNIT I: Illumination--Residential 5-2

Handout 1: Introduction 5-2

A. Recommended Illumination Chart--Specific Visual Work 5-5

B. Reflectance Percentages--Paint Colors 5-6

2: Conservation Ideas 5-7

3: Light Energy Saving Tips 5-12

UNIT II: Illumination--Commercial 5-14

Handout 1: Conservation Ideas 5-14

LIGHTING CONSERVATION OPPORTUNITIES

UNIT I: ILLUMINATION

UNIT OBJECTIVE

Upon completion of this unit the student will be able to discuss excessive illumination, waste heat, appropriate illumination, and conservation measures.

SPECIFIC OBJECTIVES

Upon completion of this unit the student will be able to:

1. Discuss the reasons for extravagant illumination in many buildings.
2. Recognize the ease in which many energy conserving tasks can be accomplished in lighting.
3. Discuss the part played by waste heat in residential and commercial illumination.

LIGHTING CONSERVATION OPPORTUNITIES

UNIT I: ILLUMINATION

HANDOUT 1: INTRODUCTION

Illumination of residences and commercial buildings accounts for around 1.5% of the national energy consumption. In office buildings in the United States the illumination provided often exceeds, by as much as a factor of 2, the amount of illumination used in comparable European buildings.

Many recent experiments confirm that lighting levels between 10 and 40 foot candles are sufficient for visual activity and physiological needs where levels of 60 to 150 foot candles are now being provided. Excess illumination imposes double energy costs. The first and most obvious is that an increase in illumination causes an increase in electrical consumption. Next, the heat generated increases air conditioning loads--for every two excessive watts of lighting, one excessive watt of cooling is needed. A 50 percent reduction in electrical usage for lighting would be near a three percent reduction in nationwide energy use. This is equivalent to the output of over thirty large commercial generating plants.

The remodeling of existing illumination systems for the reduction of energy consumption is much more easily accomplished

than the modification of other existing building components such as heating, cooling and ventilation systems.

Much extravagant illumination is caused by lighting standards--used by building codes, boards of education, industries and commercial developers-- which have risen sharply and more than doubled in many cases over the past 15 years. Yet, there is much disagreement as to whether such high illumination at such uniform intensity is needed or even desirable.

While developing a new building system for school construction in California, architect Ezra Ehrenkrantz sought to develop, among other requirements, low-brightness lighting. Each bidder was required to state the wattage required to perform the job. Bids ranged from 3.3 watts to 6.3 watts per square foot of space to meet the same performance specification. (The system using the least energy, as it turned out, was also the lowest cost.) Ehrenkrantz tallied up some numbers and figured out that a saving in energy for the average California high school of one watt per square foot was equivalent to a teacher's annual salary. "The public", he says, "is not aware of how many teachers are burned up annually with the flick of a switch."

In addition to wasting electricity, lighting emits waste heat which, in most buildings, is then dissipated into the atmosphere. A number of architects are now trying to catch

this "heat of light" and pass it through conventional ducts and vents to help heat a building.

Richard Stein in his article, Architecture and Energy, indicates that a flexible lighting system have the following characteristics: "a more efficient light source; a lighting component capable of being easily plugged in and removed as requirements change; one capable of delivering a number of levels of light; one easily controlled locally; one fitted with a light sensitive device that will turn it off if the ambient light level is adequate; and one that will accept screening devices when necessary." He continues further to suggest a universal ceiling grid into which fixtures could be plugged or removed to change the light delivery system to meet different activity requirements.

The above suggests a flexible lighting system that could easily adapt to a variety of illumination situations. This opposes the present attitude of evenly illuminating a space with large quantities of light. The hallways and storage areas are equally well lit as the work spaces. Selective lighting or task lighting is one approach in which the space is lighted compatably for the activity expected to take place. The illumination level occurring in the infrequently occupied areas would be considerably lower than the task area.

The lumen is the unit of luminous flux. It is equal to the luminous flux through a unit-solid angle from a uniform

point source of one candle, or to the flux on a unit surface all points of which are at unit distance from a uniform point source of one candle. Measure with a light meter. Some recommended illumination follows:

SPECIFIC VISUAL WORK	LUMENS/FT^2
Reading	
Fine print	70
Newspapers	30
Recreation	
Play cards	30
Table tennis	20
Grooming	50
Kitchen	
At sink	70
At range	50
Laundry	50
Sewing	
Dark fabrics, fine detail	200
Prolonged periods, light fabrics	100
Occasional	50
Handicraft	
Blue prints	100
Sawing	50

Use care in choosing finish on ceilings, walls, floors and furnishings. Dark finishes absorb light, while very light finishes can cause glare. Some reflectance percentages are:

PAINT COLOR	REFLECTANCE PERCENTAGE
White	82
Ivory	78
Yellow	75
Flesh	71
Light Pink	70
Beige	69
Light Grey	65
Lemon Yellow	64
Powder Blue	63
Aqua	61
Apricot	59
Gold	54
Rose	46
Medium Grey	45
Orange	35
Coffee	28
Kelly Green	25
Red	21
Chalk Board Green	20
Walnut Paneling	10

LIGHTING CONSERVATION OPPORTUNITIES

UNIT I: ILLUMINATION--RESIDENTIAL

HANDOUT 2: CONSERVATION IDEAS

Around five percent of the average annual electric bill is used for sight, decoration, and security. It is not wise to be wasteful, but neither should a person use bulbs that are so low in lumens that it could risk eye strain or accident nor should one sacrifice security lighting.

1. Wattage does not measure the amount of light--it measures the energy needed to light the bulb. The amount of light is measured in lumens. Study bulb packages to get the most for your wattage. Larger wattage bulbs are usually more efficient and produce more lumens per watt than smaller bulbs. It usually requires six 25-watt bulbs to give the same amount of light as only one 100-watt bulb.
2. Use efficient light sources. The various lamps available today have different properties including light output per watt input. This ranges from less than 10 lumens per watt to over 100. The choice should be the most efficient source that is appropriate to the application--light source, color, life, physical size are characteristics to be considered.

3. When lamps and fixtures have two or more sockets for incandescent light bulbs, consider using a single larger wattage bulb rather than filling all the sockets with smaller wattage bulbs.
4. Light-zone your home and save electricity. Concentrate lighting in reading and working areas and where it is needed for safety--stairwells, for example. Reduce lighting in other areas, but avoid very sharp contrasts.
5. Reduce overall lighting in non-working spaces. Remove one bulb out of three in multiple light fixtures and replace it with a burned-out bulb for safety. Replace other bulbs throughout the house with bulbs of the next lower wattage.
6. Consider installing solid state dimmers or hi-low switches when replacing light switches. They make it easy to reduce lighting intensity in a room and thus save energy.
7. Use one large bulb instead of several small ones in areas where bright light is needed.
8. Use long-life incandescent lamps only in hard-to-reach places. They are less energy efficient than ordinary bulbs.
9. Consider, when buying new lamps, the advantages of

those with three-way switches. They make it easy to keep lighting levels low when intense light is not necessary, and that saves electricity. Use the high switch only for reading or other activities that require brighter light.

10. Turn three-way bulbs down to the lowest lighting level when watching television. You will reduce the glare and use less energy.
11. Use low-wattage night-light bulbs. These now come in 4-watt as well as 7-watt sizes. The 4-watt bulb with a clear finish is almost as bright as the 7-watt bulb but uses about half as much energy.
12. Try 50-watt reflector floodlights in directional lamps --such as pole or spot lamps. These flood lights provide about the same amount of light as the standard 100-watt bulbs but at half the wattage.
13. Try 25-watt reflector flood bulbs in high-intensity portable lamps. They provide about the same amount of light but use less energy than the 40-watt bulbs that normally come with these lamps.
14. Use fluorescent lights whenever you can, they give out more lumens per watt. For example, a 40-watt fluorescent lamp gives off 80 lumens per watt and a 60-watt incandescent gives off only 14.7 lumens per

watt. The 40-watt fluorescent lamp would save about 140 watts of electricity over a 7-hour period. These savings, over a period of time, could more than pay for the fixtures you would need to use fluorescent lighting.

15. Consider fluorescent lighting for the kitchen sink and countertop areas. These lights set under kitchen cabinets or over countertops are pleasant and energy efficient.
16. Fluorescent lighting also is effective for makeup and grooming areas. Use 20-watt deluxe warm white lamps for these areas.
17. Keep all lamps and lighting fixtures clean. Dirt absorbs light.
18. Save on lighting energy through decorating. Remember, light colors for walls, rugs, draperies, and upholstery reflect light and therefore reduce the amount of artificial light required.
19. Have decorative outdoor gas lamps turned off unless they are essential for safety or convert them to electricity. Keeping just eight gas lamps burning year-round uses as much natural gas as it takes to heat an average-size home for a winter heating season. By turning off one gas lamp, you will save from $40 to $50 a year in natural gas costs.

20. Use outdoor lights only when they are needed. One way to make sure they are off during the daylight hours is to put them on a photocell unit or timer that will turn them off automatically.

21. Save energy and money by turning lights off when leaving a room. It is not true that there is an extra surge of power when a bulb is turned on. A bulb that is turned on for one second takes only one second's worth of energy.

LIGHTING CONSERVATION OPPORTUNITIES

UNIT I: ILLUMINATION--RESIDENTIAL

HANDOUT 3: LIGHT ENERGY SAVING TIPS

It is very easy to use more light than is needed. Most American homes are overlighted. Therefore, many steps can be taken to conserve energy in this category. Lighting is not a large energy item, nevertheless, it is important to practice conservation even if it merely involves turning off an unnecessary light.

LIGHT SAVING TIPS

1. Know the right light for your needs. Buy accordingly.
2. Put new bulbs where you need the most light and put the old darker ones in the basement.
3. Use sunlight, but watch heat flow.
4. Use lights over stoves and sinks, but turn them off.
5. Use fluorescent or HID lights whenever possible.
6. Use clock timers to turn lights on in the evening and off at bedtime if you plan to be away from home.
7. Use photo electric eyes to turn on security lights.
8. Keep lights clean.
9. Turn out the lights.
10. Put automatic switches on closet lights that turn off when the door closes. Close the door--this saves light and heat.

11. Get rid of the gas lights.
12. Use three-way bulbs and dimmer switches whenever possible.
13. Turn off incandescent bulbs when you leave a room, even for a minute.
14. Leave fluorescent bulbs on if you are going to be gone less than five minutes, but do come back.
15. Turn off yard lights after company arrives. Let them get into the car before you turn them off when they leave.
16. Fit the bulb size with need.
17. Use colors to help reflect available light.
18. Investigate the development of a whole new generation of low power-consumption lamps. There are now over 40 types and more coming that can be used in existing fixtures.

LIGHTING CONSERVATION OPPORTUNITIES

UNIT II: ILLUMINATION--COMMERCIAL

HANDOUT 1: CONSERVATION IDEAS

In a high-rise building nearly 54 percent of the electrical energy consumed is for lighting. This amount of lighting is usually around twice what is really needed. Some commercial energy-saver comments are as follows:

1. Consider the high-rise office buildings twinkling through the night with a full array of lights for the cleaning personnel and a few late-working executives. Selective lighting--lighting up only those rooms or parts of rooms in which someone is at work--would make a less striking skyline, but it would save a great measure on lighting. Individual switches could be installed so that lights around the perimeters of glass-walled buildings could be used only when natural light is insufficient.
2. Provide flexibility in the control of lighting. Use individual and convenient switching or dimming devices for areas that have different activity format. Photo-electric control of the electric lighting should be contemplated where sufficient daylighting is possible. Turn off lights when not needed.

Institute a program that will remind occupants to turn off lights as they leave an empty room or when daylighting is sufficient.

3. Select lighting with good cleaning capability and lamps with good lumen maintenance. Select lighting servicing plan to minimize light loss during operation and thus reduce the number of lights required. Keep lighting equipment clean and in good working order through a well-planned program of regular cleaning, relamping and servicing.
4. Post instructions covering operation and maintenance. As activity locations change, modify the lighting system and instructions accordingly.
5. Consider America with its glittering neon billboards and lighted shop windows, a major waster of now precious energy.
6. Question the necessity of the number of street lights.
7. Consider rescheduling night sporting events to daylight hours.
8. Use thermally controlled lights. Recognize lighting heat. Design the heating and cooling system to use lighting heat to reduce heating energy and to control lighting heat for minimal effect on cooling.

MODULE #6

HOT WATER HEATING CONSERVATION OPPORTUNITIES

MODULE DESCRIPTION:

This module discusses the energy conserving techniques of selecting, installing, and operating the domestic hot water system in the home.

Sizing, maintenance, and retrofit ideas are presented in terms of saving energy.

GOAL STATEMENT:

This module presents ideas for conserving energy through the installation, operation, and maintenance of one of the larger energy users--the hot water heater.

MODULE #6

HOT WATER HEATING CONSERVATION OPPORTUNITIES

UNIT I: Hot Water Installation 6-2

Handout 1: Water Heaters 6-2

UNIT II: Hot Water Operations 6-5

Handout 1: Usage and Cost 6-5

2: Control and Maintenance 6-8

A. Control 6-8

B. Maintenance 6-9

HOT WATER HEATING CONSERVATION OPPORTUNITIES

UNIT I: HOT WATER INSTALLATION

UNIT OBJECTIVE

Upon completion of this unit the student will be able to discuss the energy-saving techniques associated with domestic hot water systems.

SPECIFIC OBJECTIVES

Upon completion of this unit the student will be able to:

1. Make a better evaluation of energy-saving characteristics of domestic hot water systems.
2. Discuss several ways that energy and money can be saved by applying energy-saving techniques to hot water usage.
3. Apply proper maintenance to the domestic hot water system.

HOT WATER HEATING CONSERVATION OPPORTUNITIES

UNIT I: HOT WATER INSTALLATION

HANDOUT 1: WATER HEATERS

Hot water heating accounts for approximately 4% of all energy consumption. Energy-efficient water heaters may cost a little more initially, but reduced operating costs over a period of time can more than make up for the higher outlay.

Factors affecting water heaters:

1. Buy a water heater with thick insulation on the shell. While the initial cost may be more than one without this conservation feature, the savings in energy costs over the years will more than repay you. Select a unit with high heating efficiency.
2. Add insulation around the water heater you now have if it is inadequately insulated, but be sure not to block off needed air vents. That would create a safety hazard, especially with oil and gas water heaters. When in doubt, get professional help. When properly done, you should save about $15 a year in energy costs.
3. Placing the water heater close to points where it is needed is a fundamental requirement for minimizing water heater energy requirements. Long pipe runs result in using cold water and waiting for hot water.

The energy in the hot water remaining in the pipe is lost through dissipation. Some contractors have recognized this problem and are providing several small water heaters in larger houses, each installed near a location needing hot water.

4. Install a large-capacity uninsulated tempering tank in the supply line to the water heater, where possible. This tank will raise the temperature of incoming water to building temperature before it enters the water heater. The higher the temperature of the water supplied to the heater, the less energy will be needed to raise it to the desired tap temperature. When economically feasible, heat the water in the tempering tank with a solar panel.
5. The consumption of hot water is related to the number of persons in the family, their ages, and individual habits. Oversizing wastes energy since you are maintaining a supply of unnecessary hot water. For the average 4 member household a forty gallon oil or gas fueled hot water tank is recommended. For an electrical hot water heating system, an eighty gallon low power heater is suggested.
6. Insulate the hot water line in the crawl space under house.
7. Add a timer on an electric hot water tank.

8. If you are considering a new hot water tank, a number of energy saving models are now on the market.
9. Use the smallest diameter of hot water supply line that is practical. Less trapped water to cool means less heat loss.
10. Minimize losses of energy in pipes due to heat dissipation by insulating hot water pipes from the source to the point of use.
11. Recover the hot water discharge from kitchens, laundries, and lavatories, that is going down the drain, and pass it through heat exchangers (also use the discharge heat from the heat exchanger). The recovered heat could be used as a preheat for incoming water for hot water service.

HOT WATER HEATING CONSERVATION OPPORTUNITIES

UNIT II: HOT WATER OPERATIONS

HANDOUT 1: USAGE AND COST

Americans use and waste extreme amounts of hot water. People in other countries just can not understand us. European motel owners complain bitterly about how tourists from the United States cause their fuel bills to climb and their septic systems to be overloaded. We are spoiled. We have lavishly wasted water just the way we have squandered many of our other resources.

The average American individual uses about 20 gallons of hot water each day, thus a family of 5 uses 100 gallons of hot water each day. The following calculations will be based on a family of five.

One BTU is the amount of heat needed to raise the temperature of one pound of water one degree Fahrenheit. A gallon of water weighs 8.33 pounds, which means that it takes 8.33 BTUs to heat a gallon of water one degree.

Now, the normal temperature of ground water in most parts of the world is around 55 degrees Fahrenheit, give or take a couple of degrees. Water from a well, spring, or even a municipal water main will probably be this cold when it comes into your house. If we want to raise the temperature of this water to 155 degrees Fahrenheit, we will have to raise its tempera-

ture by 100 degrees (155 minus 55). If we then multiply 100 degrees temperature difference by 8.33 pounds--the weight of one gallon of water-- we come up with a figure of 833.

$$100 \times 8.33 = 833 \text{ BTUs}$$

This means that it takes over 800 BTUs to heat a single gallon of water to medium-hot (155°F).

The 30,000 gallons of hot water that a family of 5 uses in a year, would require 24,990,000 BTUs to heat (833 x 30,000). Of course some of this heat is lost. It leaks out of the hot water tank and creeps out of the plumbing every chance it gets on its way to the shower or dishwasher. So the 25 million BTU figure can not be accurate. It is pretty hard to say how much heat is actually lost, but we can safely guess that 2.5 million BTUs are lost in a year's time. So the real heat requirement makes the 25 million BTUs conservative.

Heating costs are most easily measured in terms of dollars per million BTUs. A million BTUs of electricity costs about $14.64 on the average. (That is figuring electricity at 5¢ a KWH or $366.00 per year).

Using current cold water detergents, the thermostat on the hot water tank could be set on 120°F and earn the following savings over a thermostat setting of 155°F.

$$\text{BTUs family of 5/yr} = 30{,}000 \text{ gal/yr} \times 8.33 \text{ lb/gal } 65F^{\circ}$$
$$= 16{,}000{,}000 \text{ BTU/yr}$$

Cost = 16 million x $14.64/million

= $234

Savings = $366 - $234

= $132/yr

The savings would actually be more because the heat loss would be much less for the 120°F.

HOT WATER HEATING CONSERVATION OPPORTUNITIES

UNIT II: HOT WATER OPERATIONS

HANDOUT 2: CONTROL AND MAINTENANCE

CONTROL

Heating water accounts for about 20 percent of all the energy we use in our homes. Do not waste it.

1. Showers, if not too long, use far less hot water than a full tub bath. Get the family into the short-shower habit. Additional hot water can be saved by replacing the standard showerhead with a low water-use showerhead.
2. Letting the water run while shaving or when washing dishes by hand is a needless waste. Avoid this by using sink stoppers and dishpans.
3. It may not be necessary to wash dishes, by hand, three times a day. Washing once will save hot water, human energy, and time.
4. Use full dishwasher loads. Use warm or cold water, whenever possible. Do not handwash before putting dishes in the dishwasher. Gas or electric bills could be lowered as much as 4% by switching entirely to cold cycles.
5. Food disposal. Always use cold water.

6. Turn down or turn off water heaters while away from home on vacations or for extended periods. If you turn off the gas pilot light, do so only according to manufacturer's instructions. If you have an electric water heater, install a timer to prevent the unit from heating during the night or while there is no one home during the day.
7. Try to choose fabrics or garments that can be washed in cold water and/or that require little or no ironing.

MAINTENANCE

As with almost every appliance, proper maintenance can help your water heater operate at its top level of efficiency.

1. The most important maintenance entails draining the sediment that collects at the bottom of the tank. Sediment can act as an insulator which prevents the efficient transfer of heat from the gas burner. Also, sediment can cause the water heater to make a rumbling noise.
2. Hard water causes lime or scale to form on heating elements, reducing their efficiency. If hard water is a problem in your area, consult your dealer. He can remove the lime or scale from the heating element when necessary. You may consider installing a water conditioner to remove mineral deposits from the water

supply before it reaches the heater.

3. Open the drain valve or faucet at the base of the tank and drain off water into a container until it runs clean, to prevent build-up of sediment in the bottom of the water tank. Sediment in the tank reduces efficiency and should be removed periodically, as required.
4. Drain the tank early in the morning before any hot water has been used. This will insure that the sediment has settled to the bottom of the tank.

MODULE #7

APPLIANCE ENERGY CONSERVATION OPPORTUNITIES

MODULE DESCRIPTION:

This module discusses the energy consumption of various household appliances, the methods of saving energy in the operation of the appliances, and the saving of energy by the purchasing of the proper appliances.

GOAL STATEMENT:

The objective of this module is to create an awareness in the student of the amount of energy consumed by appliances and of the methods available to reduce the energy usage of appliances.

MODULE #7

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APPLIANCE ENERGY CONSERVATION OPPORTUNITIES

UNIT I: LARGE ENERGY-USERS

UNIT OBJECTIVE

Upon completion of this unit the student will be able to discuss techniques of appliance purchasing, appliance opperation, and appliance maintenance; all in terms of conservation.

SPECIFIC OBJECTIVES

Upon completion of this unit the student will be able to:

1. Apply reasonably sound judgement in the purchasing of large appliances.
2. Discuss many ways to save energy in the operation of large appliances.
3. Select the proper appliance that uses the least energy, yet fills the particular need.

APPLIANCE ENERGY CONSERVATION OPPORTUNITIES

UNIT I: LARGE ENERGY-USERS

HANDOUT 1: INTRODUCTION

About eight percent of all the energy used in the United States goes into running electrical home appliances, so appliance use and selection can make a considerable difference in home utility costs. Buying energy-efficient appliances may cost a bit more initially but that expense is more than made up by reduced operating costs over the lifetime of the appliance.

Energy efficiency may vary considerably though models seem similar. A labeling program has been designed to help consumers shop for energy-saving household appliances and equipment. It was developed by the Federal Energy Administration and the Federal Trade Commission as a result of the Energy Policy and Conservation Act, signed into law on December 22, 1975.

Under that law, manufacturers must place labels showing estimated annual operating costs on all models of the following:

Air conditioners	Humidifiers
Clothes dryers	Dehumidifiers
Clothes washers	Kitchen ranges
Dishwashers	Refrigerators & Freezers
Furnaces	Water heaters

For further information about the appliance labeling program, write the Federal Energy Administration, Appliance Program, Washington, D.C. 20461.

The following are general ideas to consider when buying or using appliances:

1. Do not leave your appliances running when they are not in use. It is a total waste of energy. Remember to turn off your radio, television or record player when you leave the room.
2. Keep appliances in good working order so they will last longer, work more efficiently, and use less energy.
3. When buying appliances, comparison shop. Compare energy use information and operating costs of similar models by the same and different manufacturers.
4. Before buying new appliances with special features, find out how much energy they use compared with other, perhaps less convenient, models. A frost-free refrigerator, for example, uses more energy than one you have to defrost manually. It also costs more to purchase. The energy and dollars you can save with a manual-defrost model may be worth giving up the convenience.
5. Use appliances wisely--use the one that takes the least amount of energy for the job. For example: toasting bread in the oven uses three times more energy than toasting it in a toaster.

6. Do not use energy-consuming special features on your appliances if you have an alternative. For example, do not use the "instant-on" feature of your television set. "Instant-on" sets, especially the tube types, use energy even when the screen is dark. To eliminate this waste: use the "vacation switch", if you have one; plug the set into an outlet that is controlled by a wall switch; or have your television service man install an additional on-off switch on the set itself or in the cord to the wall outlet.

APPLIANCE ENERGY CONSERVATION OPPORTUNITIES

UNIT I: LARGE ENERGY-USERS

HANDOUT 2: REFRIGERATOR/FREEZERS

The energy required to preserve our food is third in line for home energy consumption. It follows "space cooling and heating" and "hot water heaters". Our refrigerators and freezers, therefore, give us the third greatest opportunity to conserve energy in the home.

Consider the following energy saving ideas:

1. Do not keep your refrigerator or freezer too cold. Recommended temperatures: 38 to 40 degrees for the fresh food compartment of the refrigerator; 5 degrees for the freezer section. (If you have a separate freezer for long-term storage, it should be kept at 0^{o}F., however.)
2. If you are buying a refrigerator, it is energy economical to buy one with a power-saver switch. Most refrigerators have heating elements in their walls or doors to prevent "sweating" on the outside. In most climates, the heating element does not need to be working all the time. The power-saver switch turns off the heating element. By using it, you could save about 16 percent in refrigerator energy

costs.

3. Choose the smallest refrigerator or freezer which will meet your needs--one you can keep full but not overfull. Refrigerator and freezer capacities range from 3.0 to 21 cubic feet. Remember, a large refrigerator or freezer uses more energy than a smaller one.
4. Consider buying refrigerators and freezers that have to be defrosted manually. Although they take more effort to defrost, these appliances use less energy than those that defrost automatically.
5. Do not install a refrigerator or freezer near any heat-producing appliances, and always allow for the proper air circulation around the unit.
6. Regularly defrost manual-defrost refrigerators and freezers. Frost buildup increases the amount of energy needed to keep the engine running. Never allow frost to build up more than one-quarter of an inch.
7. Try to keep your freezer full--frozen foods help retain the cold. Do not, however, put in large amounts of unfrozen food to be frozen all at once.
8. Make sure your refrigerator door seals are airtight. Test them by closing the door over a piece of paper or a dollar bill so it is half in and half out of the refrigerator. If you can pull the paper or bill

out easily, the latch may need adjustment or the seal may need replacing.

9. Open the refrigerator and/or freezer door as few times as possible. Plan ahead and remove as many items as you will need at one opening.
10. If you have a frost-free freezer, keep all liquids tightly covered. Uncovered liquids evaporate and cause a frost-free system to work harder.
11. When you go on a vacation, empty the refrigerator as much as possible and raise its temperature setting slightly.
12. Let hot dishes cool as much as possible before putting them in the refrigerator.

APPLIANCE ENERGY CONSERVATION OPPORTUNITIES

UNIT I: LARGE ENERGY-USERS

HANDOUT 3: RANGE AND OVEN

The kitchen range uses a large amount of energy and during the summer months, can put a strain on the air conditioner. Some conserving fuel-supply ideas are listed below:

1. If you have a gas stove, make sure the pilot light is burning efficiently--with a blue flame. A yellowish flame indicates an adjustment is needed.
2. If you need to purchase a gas oven or range, look for one with an automatic (electronic) ignition system instead of pilot lights. You will save an average of up to 47 percent of your gas use--41 percent in the oven and 53 percent on the top burners.
3. Follow the recommendations of the stove manufacturer as to the type of cookware you should use. In most cases, copper and stainless steel cookware require lower heat settings than does aluminum.
4. Put a self-cleaning oven into the cleaning stage right after cooking since the oven will already be far along toward the high temperature needed for cleaning.
5. Keep range-top burners and reflectors clean. They

will reflect the heat better, and you will save energy.

6. If you have a choice, use the stove-top burners or elements for foods that cook quickly and the oven for those that will take a long time. The stove-top units consume less energy, while the oven retains heat for prolonged periods.
7. If you cook with electricity, get in the habit of turning off the burners several minutes before the allotted cooking time. The heating element will stay hot long enough to finish the cooking for you without using more electricity.
8. Cook with a microwave oven whenever possible.
9. Never boil water in an open pan. Water will come to a boil faster and use less energy in a kettle or covered pan.
10. Do not turn on an element or burner until the pan is on the stove.
11. Match the size of pan to the heating element. More heat will get to the pan--less will be lost to surrounding air.
12. Do not preheat the oven unless absolutely necessary. If you must preheat, be ready to put the food in just as soon as the oven reaches the desired temperature.

13. Never preheat when broiling.
14. When using the oven, make the most of the heat from that single source. Cook as many foods as you can at one time. Prepare dishes that can be stored or frozen for later use or make all oven-cooked meals.
15. Try lower oven temperature settings when you bake in glass or ceramic dishes.
16. Watch the clock or use a timer--do not continually open the oven door to check food. Every time you open the door, heat escapes and your cooking takes more energy--also puts strain on the air conditioner.
17. Never use your oven or stove to heat the kitchen.
18. Use small electric pans or ovens for small meals rather than the kitchen range or oven. They use less energy.
19. Thaw frozen foods before cooking them.
20. Cook with as little water as possible since small amounts heat quicker.
21. Use pressure cookers and microwave ovens if you have them. They can save energy by reducing cooking time.
22. Turn down the heat as soon as the liquid you are heating reaches the boiling stage.

APPLIANCE ENERGY CONSERVATION OPPORTUNITIES

UNIT I: LARGE ENERGY-USERS

HANDOUT 4: LAUNDRY

Considerable amounts of energy in the laundry can be saved through conservation of hot water and by using automatic washers and dryers less often and more efficiently. Purchase more clothing, if necessary, to maintain proper loading.

WASHING MACHINE

1. Wash clothes in warm or cold water, rinse in cold. Save energy and use hot water only if absolutely necessary.
2. Cold or warm water can be used to wash permanent press articles, washable woolens, and lightly soiled articles. Read labels that give cleaning instructions and maximize energy conservation.
3. Fill washers--unless they have small-load attachments or variable water levels--but do not overload them.
4. Some machines offer a "gentle" or "slow-speed" wash cycle. This is accompanied by a slower-speed spin for water extraction. Less drying energy will be needed, if after completing a gentle wash the machine is reset by hand for a high-speed spin.

5. Use the suds saver if you have one. It will allow you to use one tubful of hot water for several loads.
6. Run your washer and dryer on the short cycles whenever possible.
7. Do not use too much detergent. Follow the instructions on the box. Oversudsing makes your machine work harder and use more energy.
8. Pre-soak or use a soak cycle when washing heavily soiled garments. You will avoid two washings and save energy.

CLOTHES DRYER

1. Fill clothes dryers but do not overload them.
2. Overdrying garments makes them feel rough and wastes energy. A little experimentation is needed to find the correct setting for fluff dried clothes. Some natural materials such as cotton and wool should retain some moisture to avoid wrinkling.
3. Keep the lint screen in the dryer clean. Remove lint after each load. Lint impedes the flow of air in the dryer and requires the machine to use more energy.
4. Keep the outside exhaust of your clothes dryer clean. Check it regularly. A clogged exhaust lengthens the drying time and increases the amount of energy used.
5. Dry your clothes in consecutive loads. Stop-and-start drying uses more energy because a lot goes into bringing the dryer up to the desired temperature each time you begin.
6. Separate drying loads into heavy and lightweight items. Since the lighter ones take less drying time, the dryer does not have to be on as long for these loads.
7. If drying the family wash takes more than one load, leave small, lightweight items until last. You may be able to dry them, after you turn off the power, with heat retained by the machine from earlier loads.

8. If your dryer has an automatic dry cycle, use it. Overdrying merely wastes energy.
9. Save energy by using the old-fashioned clothesline. As a bonus, clothes dried outdoors often seem fresher and cleaner than those taken from a mechanical dryer.

IRONING

1. Remove clothes that will need ironing from the dryer while they are still damp. There is no point in wasting energy to dry them thoroughly if they only have to be dampened again.
2. Buy "no iron" sheets and clothing, use the permanent press feature on your washer and dryer.
3. Save ironing time and energy by "pressing" sheets and pillow cases on the warm top of your dryer. Fold them carefully, then smooth them out on the flat surface.
4. Remove clothing promptly from the dryer and hang them carefully, many items will require no ironing.
5. Iron low temperature fabrics first to reduce warm-up time.
6. Save energy needed for ironing by hanging clothes in the bathroom while you are bathing or showering. The steam often removes the wrinkles for you.

7. Iron batches of clothing at one time to avoid wasting energy reheating the iron.
8. Be sure to turn your iron off when interrupted.
9. Prevent wasting energy by not overheating the iron.
10. Shut off the iron before completely through and finish ironing on the stored energy.

APPLIANCE ENERGY CONSERVATION OPPORTUNITIES

UNIT II: SMALL ENERGY-USERS

HANDOUT 1: INTRODUCTION

Energy can be saved by being energy conscious during the use of our small appliances. Tips that may be helpful follow:

1. A faulty appliance will not work efficiently and can waste energy. Repair or replace them immediately.
2. Many portable appliances can double as serving dishes. This will cut down the number of dishes to be washed and therefore reduce hot water and electricity consumption. The cooking energy and the number of dishes to be washed can be reduced by cooking several foods at one time in your electric skillet.
3. Use small kitchen appliances and save energy in preparation of small meals. Toasters, waffle irons, electric grills and skillets, electric coffee pots, and bottle warmers usually require less energy than the range when used correctly. As with the range, it is important to turn them off immediately after use. Keep your portable cooking appliances out of drafts.

4. Electric clocks are low wattage users, and they do not contribute very much to your electric bill. Items that are used for brief periods, like carving knives, tooth brushes, and small tools, have very little effect on your bill.
5. Be sure your dishwasher is full, but not overloaded, when you turn it on.
6. When buying a dishwasher, look for a model with air-power and/or overnight dry settings. These features automatically turn off the dishwasher after the rinse cycle. This can save you up to one-third of your total dishwashing energy costs.
7. Let your dishes air dry. If you do not have an automatic air-dry switch, turn off the control knob after the final rinse. Prop the door open a little and the dishes will dry faster.
8. Scrape dishes before loading them into the dishwasher so you will not have to rinse them. If they need rinsing, use cold water.
9. A blower-type hair dryer can consume as much energy as an electric toaster and for a longer period. Consider towel drying.
10. Empty or replace the dust bag frequently on the vacuum sweeper. A full dust bag reduces the suction and increases vacuuming time.

11. Turn off the television, radio, and stereo when no one is watching or listening. Color sets are especially expensive to operate--they consume 33% more energy than black and white sets. Instant-on TV sets use electricity 24 hours a day keeping the filaments heated and ready for operation. Unplug these when they will not be used for an extended period. Solid-state television sets, radios, and stereos require less energy than conventional sets.
12. Electric blankets allow us to set our furnace thermostats down at night and hence save energy. Turn blankets off when not in use.
13. Oil household cleaning devices as recommended by your manual to maintain maximum efficiency.

HOUSEHOLD ENERGY CONSUMPTION

The table following shows the direct energy consumption for a typical household. The consumption will vary with different living habits, climates, etc..

	ESTIMATED HOURS ANNUALLY	ESTIMATED KWH ANNUALLY
FOOD PREPARATION		
Blender	38.9	15
Broiler	69.6	100
Carving Knife	89.0	8

Coffee Maker	118.6	106
Deep Fryer	57.3	83
Dishwasher	302.2	363
Egg Cooker	27.1	14
Frying Pan	155.5	186
Hot Plate	71.6	90
Mixer	102.4	13
Oven, Microwave (only	131.0	190
Range		
with oven	96.3	1175
with self-cleaning oven	98.8	1205
Roaster	153.8	205
Sandwich Grill	28.4	33
Toaster	34.0	39
Trash Compactor	125.0	50
Waffle Iron	19.7	22
Waste Disposer	67.4	30
FOOD PRESERVATION		
Freezer (15 cu ft)	3504.4	1195
Freezer (frostless 15 cu ft)	3900.0	1761
Refrigerator (12 cu ft)	3020.7	728
Refrigerator (frostless 12 cu ft)	3791.3	1217
Refrigerator/Freezer (14 cu ft)	3487.7	1137
(Frostless 14 cu ft)	2974.0	1829
LAUNDRY		
Clothes Dryer	204.5	993
Iron (hand)	142.9	144

Washing Machine (automatic)	201.2	103
Washing Machine (non-automatic)	265.7	76
Water Heater (small wattage)	170.5	4219
Water Heater (large wattage)	107.5	4811
COMFORT CONDITIONING		
Air Cleaner	4320.0	216
Air Conditioner (room)	1000.0	860
Bed Covering	830.5	147
Dehumidifier	1466.9	377
Fan (attic)	786.5	291
Fan (circulating)	488.6	43
Fan (rollaway)	807.0	138
Fan (window)	850.0	170
Heater (portable)	133.1	176
Heating Pad	153.8	10
Humidifier	920.9	163
HEALTH & BEAUTY		
Germicidal Lamp	7050.0	141
Hair Dryer	36.7	14
Heat Lamp (infrared)	52.0	13
Shaver	128.1	1.8
Sun Lamp	57.3	16
Tooth Brush	71.4	0.5
Vibrator	50.0	2

HOME ENTERTAINMENT		
Radio	121.0	86
Radio/Record Player	1000.0	109
Television (black & white)		
tube type	2187.5	350
solid state	2181.8	120
Television (color)		
tube type	2200.0	660
solid state	2200.0	440
HOUSEWARES		
Clock	8500.0	17
Floor Polisher	49.2	15
Sewing Machine	146.7	11
Vacuum Cleaner	73.0	46

MODULE #8

BUILDING CONSTRUCTION VERSUS ENERGY CONSUMPTION

MODULE DESCRIPTION:

This module discusses the basic calculations necessary to calculate heat loss and heat gain. The heat loss of a standard house is compared with the heat loss of an energy conserving house.

Several energy saving design ideas are discussed and approximate energy saving percentages are presented for various design concepts. Some aspects of passive solar homes, underground houses and greenhouses are touched upon.

GOAL STATEMENT:

The objective of this module is to make prospective home builders aware of the large energy-saving possibilities of proper design and of well-chosen orientation of houses.

MODULE #8

BUILDING CONSTRUCTION VERSUS ENERGY CONSUMPTION

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BUILDING CONSTRUCTION VERSUS ENERGY CONSUMPTION

UNIT I: UNDERSTANDING THE ENERGY EFFICIENT HOME

UNIT OBJECTIVE

Upon completion of this unit the student will be able to discuss the major factors involved in building an energy-efficient home.

SPECIFIC OBJECTIVES

Upon completion of this unit, the student will be able to:

1. Calculate heat loss, determine heat gain, and make sizing estimates.
2. Explain the design priorities for passive solar homes and for other energy efficient homes.
3. Make an energy-consumption comparison between a standard conventional house and an energy efficient house.

BUILDING CONSTRUCTION VERSUS ENERGY CONSUMPTION

UNIT I: UNDERSTANDING THE ENERGY EFFICIENT HOME

HANDOUT 1: INTRODUCTION

The following is a passage from Xenophon's Memorablia concerning the works of Socrates (470-399 BC).

> In houses with a southerly aspect, the rays of the sun penetrate into the porticos during the winter, but in the summer the sun's path is directly over our heads and above the roofs, so that there is shade. If, therefore, this is the best arrangement, we should build the south side higher to catch the winter sun, and the north side lower to exclude the cold winds...

In 1962 St. George's County Secondary School in Wallasey, England was constructed much like Socrates' description. After the school was in operation for sometime, the conventional backup was removed because it was not used. Meanwhile back in the United States, a man--say he is a city official--sits in his office, the late afternoon sun beaming through the glass wall and flooding his desk with light. Electric bulbs burn overhead and cool air whispers from a duct as the man worries about fuel shortages and the energy crisis. He might do

better to contemplate the state of American architecture.

For architecture and the construction industry have a tremendous influence on energy use. Constructing and operating buildings consume 7.5 and 50 percent, respectively, of all the electricity produced in the United States. To practice energy conservation in this sector, we do not need to return to caves and candlelight, nor do we need new technologies.

The main problem is that the simple and technologically available ideas for saving energy are meeting tremendous indifference, if not actual resistance. Certainly it is a profound indifference to energy conservation that fosters the construction of buildings such as the 110-story World Trade Center in lower Manhattan with its fantastic array of electrical requirements, the most astounding of which is that the center will require as much electricity per year as the entire city of Schenectady, New York, which is home for more than 100,000 persons.

The energy efficient passive homes are not new in America, they just went out of vogue when cheap energy came along. Builders elected to pay little attention to passive methods of heating and cooling because it was easier and cheaper simply to overpower the weather. High priced energy in some sections of the country is reversing the trend. Research on passive homes has shown very impressive results and now builders are

turning back to the sun as a source of warmth in winter and are taking advantage of night to get rid of summer heat. Perhaps the high interest rates of 1980 will give builders time to reflect and maybe they can stop building the energy disasters and turn to buildings that can save 60 to 85% on energy bills. It is not necessary that they be underground. If you are planning a new home it might be worth your while to check into passive solar homes. Plans are becoming available even through government sources. Remember that there will be a lot of selfish interests against your attempts to save energy. Check your sources of information and be sure that there is no conflict of interest. Energy is a big business. Design inefficiency in the United States has contributed to an enormous waste of materials and energy. Cost-saving techniques have been pushed aside by a combination of economics, absurd building codes and unions.

Architects still tend to design houses for themselves and other architects without regard to energy or what people really need or want. Builders of houses that utilize space, energy, and materials in a thoroughly engineered manner to get the most for the least have a back-log while the conventional builder is relatively idle.

This module will discuss energy-efficient house design, including amounts of insulation, types and sizes of windows, size and shape of the house, orientation, underground and energy conserving ideas for the existing house.

BUILDING CONSTRUCTION VERSUS ENERGY CONSUMPTION

UNIT I: UNDERSTANDING THE ENERGY EFFICIENT HOME

HANDOUT 2: HEAT LOSS, GAIN, AND BASIC CALCULATIONS

There has not been much need in the past to make detailed heat load calculations for residential buildings because the HVAC contractor "knew", from his experience, the size of furnace that a particular building would require in a given area. Furnaces have been characteristically oversized for residential buildings.

With new energy prices and expensive solar systems, heating loads for buildings should be calculated. The determination of the economic viability of a solar system is dependent upon the size of the solar system and the annual heating load.

The heat loss from a building is calculated on the basis of the wall and ceiling areas of the building, the heat loss coefficients for heat transmission through the walls and ceiling, the difference between the indoor and outdoor temperature, and the infiltration of cold air into the building.

Values of the resistance to heat flow, R, and the coefficient of heat transmission, U, vary considerably for

different materials. The resistance, R, has units of (hr)$(ft^2)(^oF$ temperature difference)/BTU and is the reciprocal of heat conductance, C. For a given material and thickness,

$$R = 1/C$$

where C is the conductance in $BTU/(hr)(ft^2)(^oF)$.

The thermal conductivity, k, is the rate of heat conduction through a unit area of surface for a unit thickness of material. The units of k in this manual are $(BTU)(in)/(hr)(ft^2)(^oF)$. If k is known, the resistance may be calculated from

$$R = (1/k) \times (\text{thickness of the material}).$$

Values of R are additive, and the coefficient of heat transmission, U, is the reciprocal of the sum of the R values:

$$U = \frac{1}{R_1+R_2+R_3+\ldots} = \frac{1}{\Sigma R} \quad \frac{BTU}{(hr)(ft^2)(^oF \text{ temperature differ.})}$$

Some values of R, U, and 1/k are given in Table 2-1.

Heat Loss Rate

The rate of heat loss, h, in BTU/hr through a surface of area, A, with a temperature difference across the two sides of the surface of ΔT, is:

$$h = UA\,\Delta T$$

where A is in square feet and ΔT is in degrees Fahrenheit.

Table 2-1

Values of R, U, and 1/k for Some Structural and Finish Materials, Glass, Doors, Insulation, Air Spaces, and Surface Air Films †

Materials	1/k	R	U
Wood bevel siding, .5 x 8, lapped		0.81	
Wood siding shingles, 16" x 7.5" exposure		0.87	
Asbestos-cement shingles		0.21	
Stucco	0.20		
Building paper		0.06	
1/2"nail-base insulation board sheathing		1.14	
Insulation board sheathing, regular density	2.63		
Plywood	1.24		
1/4" hardboard		0.18	
Softwood board	1.25		
Concrete blocks, 3 oval cores			
Cinder Aggregate 4" thick		1.11	
Cinder Aggregate 12" thick		1.89	
Cinder Aggregate 8" thick		1.72	
Sand and gravel aggregate, 8" thick		1.11	
Lightweight aggregate, 8" thick		2.00	
Concrete blocks, 2 rectangular cores			
Sand and gravel aggregate, 8" thick		1.04	
Lightweight aggregate, 8" thick		2.18	
Common brick	0.20		
Face brick	0.11		
Sand-and-gravel concrete	0.08		
Gypsumboard (plasterboard)	0.90		
.5" lightweight-aggregate gypsum plaster		0.32	
25/32" hardwood finish flooring		0.68	
Asphalt, linoleum, vinyl, or rubber floor tile		0.05	
Carpet and fibrous pad		2.08	
Carpet and foam rubber pad		1.23	
Asphalt roof shingles		0.44	
Wood roof shingles		0.94	
3/8" built-up roof		0.33	
Basement floor below grade			0.06
Glass			
Single			1.13
Double 1/4" air space			0.65
Double 1/2" air space			0.58
Triple 1/4" air spaces			0.47
Triple 1/2" air spaces			0.36
Storm windows (1-4" air space)			0.56

† From ASHRAE Handbook of Fundamentals

Table 2-1 (continued)†

Solid Wood Slab Door U Values:	No Storm Door	Storm Door	
		Wood	Metal
1.00" thick	0.64	0.30	0.39
1.25" thick	0.55	0.28	0.34
1.50" thick	0.49	0.27	0.33
2.20" thick	0.43	0.24	0.29

Insulation:	1/k	R	U
0" thick		0	
2.0 - 2.75" thick	3.58	7	
3.0 - 3.5" thick	3.58	11	
3.5 - 3.625" thick	3.58	13	
5.25 - 6.5" thick	3.58	19	
6.0 - 7.0" thick	3.58	22	

Approximate U values for ceiling, walls, and floors (other than concrete slabs) with given insulation (R value). If heating unit is in the basement and if ducts or pipes are uninsulated, no floor loss calculation is necessary. For floors over unheated basements, use 1/3 of the approximate U value given or 1/3 of the calculated U value. For floors over unvented crawlspaces with insulated crawlspace walls, use 1/2 of the approximate U value given or 1/2 of the calculated U value. For floors over vented crawl spaces or other open spaces, use the approximate U value given or the calculated U value. Use of the approximate U values given here for a given R value will usually result in a higher heat load than will actually be the case.		0 7 11 13 19 22	0.28* 0.11 0.08 0.07 0.05 0.045

Concrete Slab Floors: Use linear feet of exposed length of slab edge in place of A:h = U (lin. ft) ΔT			
1" x 24" insulation			0.21
1" x 12" insulation			0.46
No insulation			0.81

Air Spaces (3-4")	Heat Flow Up	Non-reflective		0.87	
		Reflective, 1 surface**		2.23	
	Heat Flow Down or Horizontal	Non-reflective		1.01	
		Reflective, 1 surface**		3.50	
Surface Air Films	Heat Flow Up	Non-reflective		0.61	
		Reflective		1.32	
	Heat Flow Down	Non-reflective		0.92	
		Reflective		4.55	
	Heat Flow Horizontal	Through vertical surface, non-reflective		0.68	
	Outside (15 mph wind)			0.17	

* When R = 0, actual U values may range from 0.2 to 0.5

** The addition of a second reflective surface facing the first reflective surface increases the thermal resistance values of an air space only 4 to 7%.

† From ASHRAE Handbook of Fundamentals

The temperature difference that is used to calculate the heat loss rate is the difference between the room temperature, T_R, and the design outdoor temperature, T_o:

$$\Delta T = T_R - T_o$$

The room temperature is nominally 70 degrees and the design outdoor temperatures are listed in Table 2-2 for some cities in Kansas. Also listed on the table are monthly and total annual heating degree days, which will be utilized in the heating load calculations.

Table 2-2

KANSAS	NORMAL TOTAL HEATING DEGREE DAYS (Base 65°)									Design T_o °F	
	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	ANNUAL	WIN	SUM
Concordia	705	1023	1163	935	781	372	149	18	5479		
Dodge City	666	939	1051	840	719	354	124	9	4986	3	99
Goodland	810	1073	1166	955	884	507	236	42	6141	-2	99
Topeka	672	980	1122	893	722	330	124	12	5182	3	99
Wichita	618	905	1023	804	645	270	87	6	4620	5	102

Concrete Slabs On Grade

The heat loss rate from concrete slab on grade is calculated on the basis of exposed edge length rather than on floor area. The heat

loss rate is:

$$h = U \text{ (linear feet of exposed slab area) } \Delta T$$

where ΔT is the difference between indoor and average outdoor temperature in degrees Fahrenheit.

The U values are listed in Table 2-1.

Basements

Basement floors below grade have a heat loss rage of about $\frac{1 \text{ BTU/hr}}{\text{ft}^2 \text{ of floor area}}$. In Table 2-1, for basement walls below grade, $U = 0.06 \text{ BTU/(hr)(ft}^2\text{)(}^{\circ}\text{F)}$. The temperature difference is the indoor temperature minus the ground temperature, and the ground temperature is often assumed to be the same as ground water temperature and, in most regions, can be assumed to be about 45°F in winter.

Duct Heat Loss

When a duct is installed within the insulated envelope, there is no heat loss from the building. If the ducts are located in crawlspaces or outside the building envelope, about 10 percent of the heat carried by the duct will be lost.

Infiltration Heat Loss

The cold air that enters a building through open doors, windows and cracks around doors and windows constitutes a heat loss because the cold air displaces the warm room air and the cold air must be heated to

room air temperature. The infiltration heat loss rate can be computed from:

$$h = 0.018\ V(\Delta T)$$

where V is the volume flow rate, cubic feet of cold air per hour and

Δ T is the difference in indoor and outdoor air temperatures.

The volume flow is the air change rate per hour. For normal residential buildings, the air change rate averages about once per hour for all rooms located above grade.

SPACE HEATING LOAD

The sum of the heat transmission losses through the building enclosure and the infiltration losses is the design hourly heat loss rate for the building. The space heating load for a building, based on heating degree-days (DD), is calculated from the design heat loss rate as follows:

$$\frac{\text{Design Heat Loss Rate}}{\text{Design Temperature Diff.}} \times 24 = \text{Space heating load, BTU/DD}$$

The monthly and annual heating loads are then calculated using the heating degree-day values in Table 2-2 as:

$$\text{Heating Load (BTU)} = \frac{\text{BTU}}{\text{DD}} \times \text{(heating degree-days)}$$

As an example, assume that a building has a heat requirement of 16,000 BTU/DD. The January heating degree-days is 1000, and the annual heating degree-days is 5000. The heat required in January is:

$$16{,}000 \frac{BTU}{DD} \times 1000\ DD = 16\ m\ BTU$$

and the annual heat requirement is:

$$16{,}000 \frac{BTU}{DD} \times 5000\ DD = 80\ m\ BTU \text{ per year.}$$

DOMESTIC HOT WATER HEATING LOAD

The amount of hot water used in residential buildings is about 20 gallons per person per day and the heat required to raise the temperature of the incoming water from about 40°F in winter to 140°F can be computed from:

$$H_w \left(\frac{BTU}{day}\right) = (\text{No. of occupants}) \times 20 \frac{\text{gallons}}{(\text{person})(\text{day})} \times 1 \frac{BTU}{(lb)(^\circ F)} \times (140 - 40^\circ F) \times 8.34 \frac{lb}{gal}$$

or,

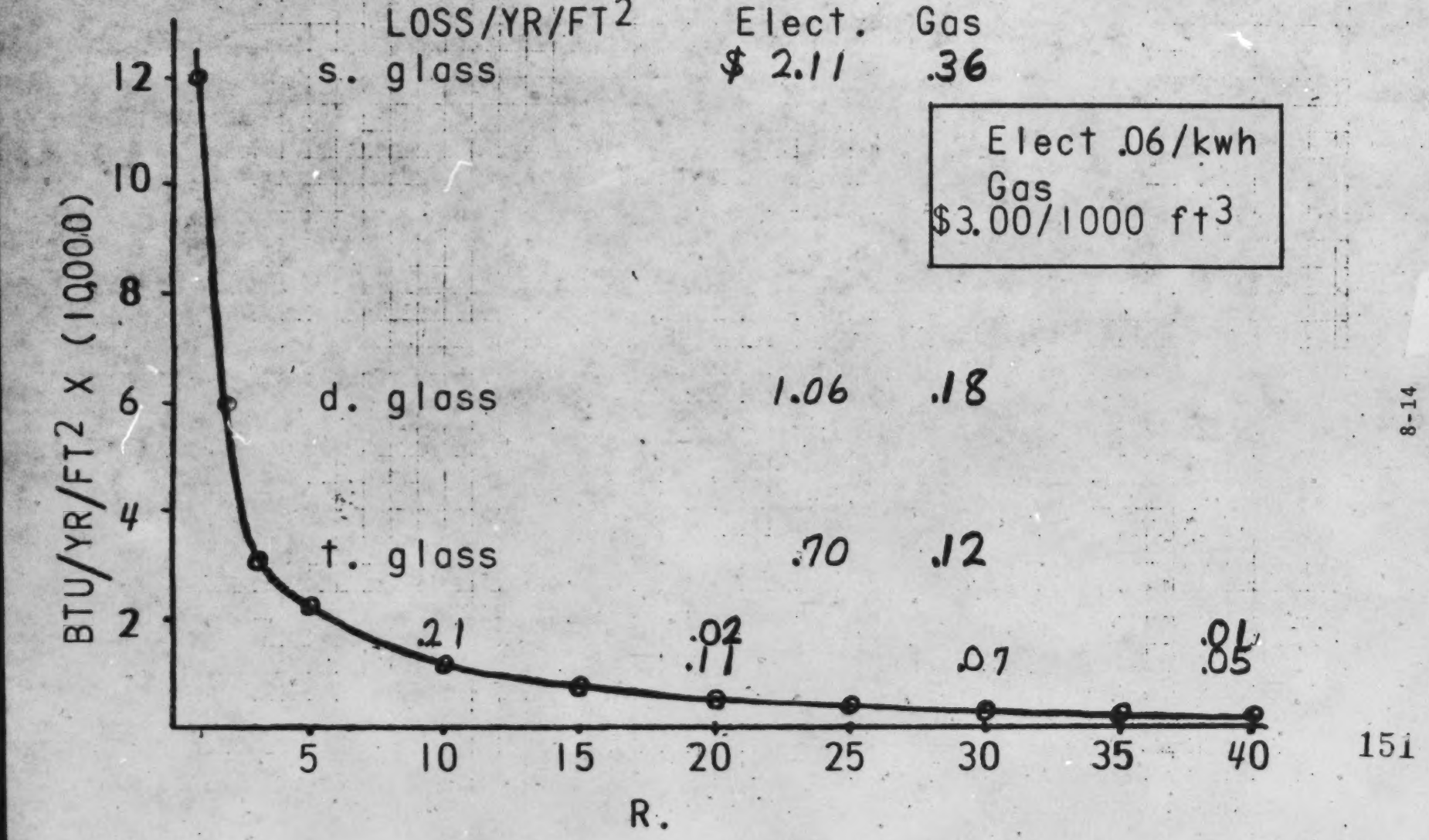
$$H_w = (\text{No. of occupants} \times 16{,}680 \frac{BTU}{(\text{person})(\text{day})} .$$

Until recently, people referred to insulation requirements in terms of the number of inches of insulating material needed. Now, however, these rough quantitative figures have been replaced by a more realistic gauge--the R-value. A material's R-value refers to its resistance to heat passing through it. The larger the R-value, the greater its insulating ability.

Insulation materials include a variety of R-values. But, since these materials also vary in terms of flammability, installation problems, etc., selection should be based on a knowledge of all the properties of common insulation materials.

The graph on the following page represents the heat loss in BTU/yr/ft^2 of building materials with different R-values for an area having 5000 degree days. The cost of the lost energy for selected R-values are indicated for both electricity and gas heating.

The graph shows that at the present time it would be cost-effective to increase the R-value of the ceiling from R-20 to R-30 if you are heating with electricity, but not if you are heating with gas.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R.

8-14

BUILDING CONSTRUCTION VERSUS ENERGY CONSUMPTION

UNIT I: UNDERSTANDING THE ENERGY EFFICIENT HOME

HANDOUT 3: DESIGN PATTERNS

Building design should go beyond the standard energy-conserving construction used by good builders of today. Our energy dilemma calls for additional energy conservation by incorporating passive design ideas, and by using solar energy through passive systems, in its planning, design, construction and use. Building location, siting, orientation, configuration, layout, construction, mechanical and electrical systems, casework, and interior furnishings are all carefully evaluated in terms of their contribution to energy consumption and conservation. Natural energies are used to their fullest.

Some design priorities follow:

1. Make every effort in planning, design and construction to minimize heat loss in the winter and heat gain in the summer.
2. With this objective achieved, put forth every effort to incorporate into houses passive design characteristics which use natural energies such as solar radiation, natural lighting and prevailing winds.
3. Where possible, economical and efficient, incorporate

active technologies which use renewable energies into designs.

4. Then, and only then, should we rely on fossil-based or non-renewable energies (and related equipment and design features) to supply the remaining energy required.

Passive design concepts that require no change in life style might include:

1. One-story building configuration
2. Earth berming to the window sills
3. Reflective surfaces within the envelope
4. Flexible walls
5. Atrium/greenhouse
6. Individual hot water system
7. Entry locks
8. Closets located against exterior walls
9. Individual heating zones with clock thermostats
10. Window sash and insulated glass
11. Window shutters

Management ideas might include:

1. Temperature during heating season maintained at 70°F during occupied times and 55°F at all other times is a management priority.

2. House includes operable shutters (U value: .115) which are open from 8 a.m. to 4 p.m. in the winter-time. Summer schedule for shutters on east windows is 1 p.m. to 4 p.m.; shutters on south windows, 7 a.m. to 9 a.m. and 3 p.m. to 5 p.m.; west windows, 8 a.m. to 11 a.m.; and north windows, 8 a.m. to 7 p.m.

ORIENTATION FOR SOLAR GAIN AND FOR NATURAL VENTILATION

Some compromising will be necessary because solar gain and natural ventilation cannot always be maximized by the same orientation.

1. For passive solar collection, south-facing glass should total 1/4 to 1/5 of the floor area (temperate climates) or 1/3 to 1/4 of the floor area (colder climates). These are general rules which, in temperate climates, and with appropriate insulated shutter and heat storage mass, can provide between 40% and 90% of the heating required.
2. Use an isogonic chart to locate 'south'. (Remember, a compass indicates magnetic, not true, north.) Additional data on solar altitude and bearing for your area, and for critical times of the year, are available from the Weather Bureau or Solar Atlases.

3. Be sure that trees, hills and/or buildings do not cast shadows on your south-facing glass during the winter. (Also insure that your building does not infringe on the 'solar rights' of others.)
4. Design overhangs to provide full shading of glass areas in the summer and during the most intense solar insolation periods. Deciduous trees on the south side will also help--providing shading in the summer and permitting solar penetration in the winter.
5. In orienting the building, remember that each facade has its own climatic conditions and thus its own energy conscious design characteristics. As an example, vertical shutters may be appropriate on one facade, horizontal on another and sliding on a third.
6. Locate the facade through which breezes will enter at an angle of 20^{o} to 70^{o} between wall and wind direction. This increases turbulance and provides better ventilation.
7. When wind velocity is low, it is beneficial to maximize the velocity of the ventilating currents. This can be done by using wing-walls extending from the exterior wall to create mini-pressure zones in front of the window openings. The depth of the projection should be no more than one-half of the distance between windows on the same facade. Casement windows,

or operable shutters, extended perpendicularly to the wall can serve the same function.

8. Window sills should be located at the height where ventilation is desired. In bedrooms, for example, sills should be located at the same elevation as the mattresses inside.
9. Locate evergreens on the north and west sides to block arctic winds.
10. When sites slope, particularly to the south, breezes move up the hill by day and down at night. Near bodies of water, breezes move from water to land by day and from land to water at night.

Some general rules to keep in mind while designing a passive solar collector:

1. Locate a maximum amount of living space so that it has a southern exposure.
2. Use true north--not magnetic north--in locating the south elevation.
3. The amount of south-facing glass area depends on the amount of passive heating desired and the insulation characteristics of the site. As general guidelines, include 1/4 to 1/5 of the floor area to be heated as south facing glass in temperate climates. In colder

climates, increase the ratios to 1/3 to 1/4 of the floor area.

4. To store heat, sufficient water, masonry and other storage media are required. In temperate climates, and where surfaces will have direct exposure to the sun, provide 30 pounds of water or 150 pounds of masonry for each square foot of south-facing glass. Where exposure to the sun is indirect, the mass of the material will have to be increased (by a factor of four).
5. For storing the heat energy, think of all fixed elements in the structure (walls, floors, ceilings, furniture, flower beds, etc.) as heat storage masses. The ratio of building floor area to storage mass surface area should be at least 1:1.
6. Masonry or concrete wall thickness of more than 8" has little effect on daily thermal storage. Thicker walls, however, will help store heat for cloudy days.
7. The surfaces of thermal masses should be dark where possible. Use light colors on floors to prevent excess surface temperatures.
8. Insulating shutters are essential components of passive solar systems. Use them on the exterior to keep heat in at night, and on the inside to keep heat

from radiating into the room when it is not desired.

9. Shade glass walls to reduce heat gain when it is not wanted. To do this, determine the sun's altitude at noon during the hottest summer month, and design your shade or roof overhang to put the entire wall in shade. For winter conditions, find the sun's altitude at noon in the coldest month; your overhang should leave the full wall in as much sun as possible.

Ideas to keep in mind before building underground:

1. Gentle south slopes are ideal for underground structures. You can easily build into the hill, have south sunlight and positive drainage.
2. Avoid low-lying depressions. Heavy cold air drains into them; frost and dampness are more likely in these areas.
3. Make sure that surrounding construction (parking lots, septic systems, etc.) do not drain into the site.
4. Identify ground water levels (including seasonal variations) before making decisions on placement and depth.
5. Adequate soil percolation is essential, particularly for sunken courtyards and atriums. If there are problems, consider the installation of overflow drains.
6. Any structural system can be used, provided it is designed to applicable loading conditions. General

rules are 150 PSF for roofs with grass cover, and 400 PSF for roofs when the earth cover is to support small trees. Add snow, water and pedestrian loads.

7. Wall design is generally the same as conventional basement wall or other below-grade construction.
8. Place insulation on the outside of the below-ground building structure; this allows the structure to serve as a heat-storage mass. Insulation can be reduced in thickness as the depth below grade increases. The best current insulating material for this application is styrofoam with its closed cell construction.
9. Butyl sheets provide both waterproofing and a vapor barrier.
10. For earth berming against existing exterior walls, a cement plaster finish applied to metal lath and a vapor barrier on the existing wall will do the job. This detail also discourages roots, insects and rodents from getting into the wall.
11. Avoid curbs or parapets to retain earth roof covering. Freezing and thawing action will tend to crack these elements.
12. To control interior dampness, dry the air through circulation and/or dehumidification.

13. Earth pipes can be used to provide natural cooling. Air taken from the outside during warm weather can be cooled by passing it through long pipes buried in the berm or below grade. The same piping can provide some degree of preheating fresh outside air during cold weather.
14. Examine local codes, especially in relation to fire exits and ventilation.
15. Lighting usage should be thought out carefully. It will affect both comfort and energy use more critically in an underground house.

Underground structures are now the subject of a great deal of research. Before embarking on such an undertaking, a review of the latest research results is highly recommended.

Greenhouses attached to residences can perform two key passive design roles:

1. as secondary skins, effectively raising the temperature just outside the building's exterior wall in the winter (and, if plants and shading devices are used, lowering it in the summer) and
2. as passive solar collectors.

For passive design purposes, these simple rules-of-thumb may be of value:

1. A greenhouse can be constructed as a secondary skin on any facade--but a south-facing greenhouse makes the best passive solar collector.
2. The wall between the greenhouse and the residence must be insulated to control heat flow and to prevent overheating.
3. Wall surfaces directly exposed to the sun should be dark-colored. Floors should be light-colored if there is danger of them becoming too warm.
4. Insulated shutters allow the greenhouse to retain the heat collected after the sun has gone down.
5. The distance from the exterior wall of the greenhouse to another object on the landscape (a tree, another building, etc.) should be at least 2½ times the height of the wall.

Building an attached solar greenhouse is rapidly becoming popular as a source of energy, of fresh food and/or of flowers right through the winter. A traditional greenhouse usually was constructed without much regard for the most effective use of the sun's energy. A solar greenhouse, if constructed properly, will collect solar energy efficiently, store solar energy, reduce heat loss and provide light zoning for various plants.

BUILDING CONSTRUCTION VERSUS ENERGY CONSUMPTION

UNIT II: BUILT-IN ENERGY SAVINGS

HANDOUT 1: INTRODUCTION

Housing is a major consumer of energy in this country. Nearly 20% of the total energy pie or 3 billion barrels of crude oil per year is used in our nearly 100 million households.

Studies have suggested that a 25% to 35% reduction in the heating component is possible by making standard energy conservation practices. Further studies show that it is possible to extend the 25% to 35% energy savings by going beyond the standard energy conservation practices and use passive design concepts which:

1. Rely on natural energy, such as that produced by the sun.
2. Contain few mechanical parts or complex hardware.
3. Require little or no energy themselves.
4. Tend to be low in cost.

STANDARD ENERGY CONSERVATION PRACTICES
OUTLINE

1. Glass
   A. Multiple glazings (insulating glass)
   B. Storm windows

C. Internal shading: draperies, blinds, and roller shades

D. Removable, insulated panels. These panels are manually placed over glass areas, from the inside.

E. External shading: shade screens, shutters, awnings, overhead projections.

F. Reduced glass areas on north and west sides of building.

2. Outside Walls

A. Fill stud space completely with thermal insulation. Include a vapor barrier between insulation and conditioned space.

B. Use insulating sheathing

C. On existing homes where it is not practical to add insulation, apply insulating, exterior siding.

3. Partition Walls (walls between conditioned and non-conditioned spaces, such as a wall between house and an attached garage.)

A. Fill stud space completely with thermal insulation. Include vapor barrier as with outside walls.

B. Keep garage doors closed on attached garages, especially in winter.

4. Floors

   A. Over crawl space

      1. Thermally insulate floor.

      2. Close north side vent openings in winter.

   B. Concrete slab on ground

      1. On new construction, thermally insulate inside surface of perimeter beam and under floor for several feet.

      2. On existing construction, thermally insulate exterior surface of slab perimeter.

5. Roof

   A. Insulate to thickness recommended for geographic location. Place vapor barrier between insulation and conditioned space.

   B. Provide proper attic ventilation.

6. Infiltration

   A. Caulk under sole plate and around holes for plumbing and electrical wiring. This is possible only for new construction.

   B. Caulk around door and window casings in brick veneer homes.

   C. Caulk around door, window, and corner facings and in corner joints in frame homes with wood siding.

   D. Weather strip around all doors and windows.

7. Fireplaces

   A. Combustion air requirements

   B. Combustion air ducts

   C. Effects on air infiltration

   D. Net heating effect

8. Internal Loads

   A. Kitchen range: use of exhaust hoods

   B. Lights: fluorescent versus incandescent

9. Thermostat Settings

   A. Use higher setting in summer

   B. Use lower setting in winter; even lower during sleeping hours

   C. Shut off system completely when away for extended periods of time.

   NOTE: The above statements are general in nature and could actually result in little or no energy savings, damage (i.e., frozen pipes), and totally unacceptable comfort conditions.

10. Heating/Cooling System

   A. Clean or replace filters.

   B. Assure that ductwork in attic is properly insulated.

   C. Install ductwork within conditioned space if possible.

D. Ductwork and all appurtenances must be properly sized and located.

E. Do not close off outlets in unused rooms. This has the same effect as a dirty filter.

F. Equipment capacity must be determined by load calculations.

G. Keep outside condensing coil free of leaves and other obstructions.

H. Seasonal routing maintenance of equipment.

11. Miscellaneous

A. Leaking faucets, especially hot water.

B. Flush sediment from water heater tanks.

C. Deciduous trees. Properly located, they can shade building in the summer and allow the benefit of the sun in winter.

BUILDING CONSTRUCTION VERSUS ENERGY CONSUMPTION

UNIT II: BUILT-IN ENERGY SAVINGS

HANDOUT 2: PASSIVE DESIGN IDEAS AND PERCENTAGE ESTIMATES

This section compares the energy savings of a house that incorporates all of the standard energy conservation practices from Handout 1, with the energy savings of a house that possesses equal standard energy conservation practices from Handout 1, plus some of the following passive design ideas. The percentages given have been derived from specific designs, but the purpose here is to present a rough idea of the energy saved by incorporating certain passive design concepts.

It is feasible to include many combinations of the passive design concepts presented here in a single residential building. When this is done, however, the percentage energy savings given for each of the individual concepts cannot be simply added together to derive a cumulative energy saving.

DESIGN CONCEPTS AND ENERGY SAVINGS

Save heating and cooling energy in the home by:

1. Earth berming up to the window sills of a one-story square-plan house--energy savings around 13%. This presents no interference to ventilation or view and makes a minimal visual change in the appearance of

the house.

2. Earth berming to a depth of 6 feet of a one-story square-plan house--energy savings around 32%. Re-read (Unit I) ideas to keep in mind, before building underground.
3. Locating bedrooms below grade to a depth of 6 feet and placing the living area on the second floor--energy savings around 23%. This is not a new notion, but people often resist the idea of being below ground level. Yet, bedrooms and associated baths, dressing and storage spaces are generally used in the evening hours and the impact can be dramatic.
4. Building an underground house with covered atrium--energy savings around 45%. Do research prior to building underground. See Unit I.
5. Using managed insulated window shutters (R=8.7)--energy savings around 28%. Real window shutters, operable and insulated, have significant energy-saving potentials.
6. Using managed bead windows--energy savings around 34%. The bead window consists of two glass sheets separated by a 3" air space. This space can be filled with styrofoam beads, using a small pump and blower system, to improve thermal resistance.

7. Lowering ceilings by one foot--energy savings around 9.6%. The volume to heat is less.
8. Placing closets, hide-a-beds, and other furniture on outside walls--energy savings around 14.8%. This adds insulation and reduces the volume to be heated or cooled by reducing floor area.
9. Installing domestic hot water heat recovery--energy savings around 26%. Channel hot water from showers, baths and lavatories through a heat exchanger to preheat the cold water before it enters the domestic hot water system.
10. Attaching a greenhouse--energy savings from 5% to 50%. There can be a large variance in size, mass, and orientation.
11. Constructing a passive solar house that is properly designed, oriented, and sized--energy savings around 60% to 80%. Living life-style can broaden the savings spectrum.

MODULE #9

HEATING, VENTILATING, AND AIR CONDITIONING CONSERVATION

MODULE DESCRIPTION:

This module discusses the principles of heating and cooling in buildings such as heat loss, heat gain, heating loads, and cooling loads. Heating load and cooling load characteristics for sizing home heating and cooling equipment requirements are discussed in terms of relative humidity and summer and winter design temperatures.

Heating and cooling equipment are presented in terms of components of operation, energy efficiency ratings, and equipment energy usage and design. Ductwork is explored as the delivery system of home conditioned air. Cost/benefit analysis of energy conservation opportunities in heating, ventilating, and air conditioning are explored in the areas of equipment operation, maintenance, and control.

GOAL STATEMENT:

The objective of this module is to train individuals in the recognition of energy consumption and the implementation and utilization of energy conservation in heating, ventilating, and air conditioning.

MODULE #9

HEATING, VENTILATING, AND AIR CONDITIONING CONSERVATION

UNIT I: Fundamentals of Heating and Cooling 9-2

Handout 1: Introduction 9-2

2: Energy Units 9-6

Activity 9-10

3: Temperature Differences 9-11

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HEATING, VENTILATING, AND AIR CONDITIONING CONSERVATION

UNIT I: FUNDAMENTALS OF HEATING AND COOLING

UNIT OBJECTIVE

Upon completion of this unit the student will be able to discuss energy measurements, temperature differences, and humidity factors as it applies to energy conservation in heating, and cooling systems.

SPECIFIC OBJECTIVES

Upon completion of this unit, the student will be able to:

1. Discuss energy use in heating and cooling systems in relation to the types of fuel used.
2. Identify units of measurement for energy fuel used in heating and cooling.
3. Explain temperature differences as it applies to heating and cooling homes in various locations.
4. Point out the relationship of humidity to heating and cooling.

HEATING, VENTILATING, AND AIR CONDITIONING CONSERVATION

UNIT I: FUNDAMENTALS OF HEATING AND COOLING

HANDOUT 1: INTRODUCTION

Non-renewable energy (coal, gas, and oil, is used in our homes). Due to diminishing supplies, curtailments, and real or fabricated shortages, energy prices are rising; in no area do we experience this more than in our heating and cooling bills. As shown in Figure 1.1, 15.7 percent of our total U.S. energy budget is devoted to heating (space and water) and cooling (air conditioning and refrigeration). When we search for ways to simplify our lifestyles, there is no better place to start.

Figure 1.1

ENERGY USE
Percent of Total U.S. Energy Use in Residential Sector

Wood	nil	
Coal	nil	
Natural gas	7.3%	
Electricity	7.5%	
Oil	4.4%	
Total	19.2%	
Space heating	11.0%	
Water heating	2.9%	15.7%
Air conditioning	0.7%	
Refrigeration	1.1%	
Cooking	1.1%	
Lighting	0.7%	
Other (small appliances)	1.7%	
Total	19.2%	

We can maximize efficiency by insulating homes and offices. Keeping out heating and cooling systems in proper working order will also cut costs. We can operate energy-wasteful appliances only when it is absolutely necessary and at non-peak load hours;

and everyone should practice conservation measures such as using hot water sparingly.

This module will discuss the design, installation, and proper use of space heating and cooling systems for the home and will touch on energy saving tips for the consumer. Once a basic house is designed, including amounts of insulation, types and sizes of windows, size and shape of the house, and orientation, the homeowner must then determine the heat loss and heat gain requirement of a building so that a balance between the two can be obtained by properly adding a space heating system and a cooling system. This is one of the most important considerations in discussing energy abuse in a home.

The first step in reducing energy consumption and fuel bills is to understand some of the basic principles of heating and cooling. Most energy is consumed in the home by the operation of furnaces, air conditioners, ovens, and refrigerators. By understanding how heating and cooling take place, one can gain a real insight into the factors that make these units work efficiently.

First, one must always remember that the total heating or cooling bill depends upon two factors:

1. The efficiency of a furnace, and
2. The efficiency of an air conditioner (or other appliances and the amount of work required).

Efficiency is a measure of how much energy is wasted in doing a particular job; 100% efficiency means no wasted energy, while

50% means half is wasted. A fact too often ignored is the actual amount of work required to do the job. A poorly insulated house requires far more energy to heat and cool than a well insulated house. Sealing air leaks, adding more insulation, and doing other simple jobs can do far more to reduce fuel bills than buying the most advanced, expensive, high-efficiency furnace or air conditioner on the market.

Most homes today have fully controlled temperatures all year around. In the winter the home is heated by a furnace; in the summer it is cooled by an air conditioner. The inside temperature is regulated by a thermostat. Although there are many different types, brands, and models of heating and cooling equipment, the basic purpose is the same--to keep the occupants at a comfortable temperature.

Thermostat control provides one of the easiest ways of maintaining the house in a comfort system and reducing the amount of energy necessary. Thermostats can be single or can be multiple with some sort of switching option. In thermostat control the first basic thing is to decide what your schedule is, when you will be in the home, out of the home, and adjust the desired base line temperatures accordingly. Most people do not think to turn thermostats down when they leave or to turn thermostats down at night. But, by this choice of options using some sort of programmed clock thermostat which can either be day or nighttime or which can be a seven-days thermostat. An appreciable savings of maybe 10-15-20% can be made in the over-

all fuel cost and utility bill by just turning the furnace down at night shall we say to 60-64°F and maybe maintaining it in the day at about 68-70°F. Obviously, when one is out of the home completely, the furnace can be turned down to the lowest setting for periods where one will be gone more than 6-8 hours.

Heating and cooling a home costs money. Electricity is consumed, gas and oil are burned, and one pays for what is used. The object then is to use as little energy as possible to heat and cool the home. Using efficient equipment is one way to cut down energy consumption, and adding insulation is another. Efficient equipment makes it possible to use energy in the least wasteful manner, while insulation slows down the escape of heat energy in the winter and the entrance of heat in the summer.

HEATING, VENTILATING, AND AIR CONDITIONING
CONSERVATION

UNIT I: FUNDAMENTALS OF HEATING AND
COOLING

HANDOUT 2: ENERGY UNITS

Energy Units is something bought in measured amounts. Different kinds of energy come in different forms and are measured using different units. For example, one buys natural gas by the cubic foot, gasoline and fuel oil by the gallon, and coal by the ton. But energy consumption does not take place instantly--it takes time to use up the fuel.

The output of a candle is actually one BTU per hour. Home heating requirements are figured in BTU. The heat load is the amount of heat that escapes from the structure through walls, windows, doors, ceilings, floors, etc. If a house has a 100,000 BTU heat load (figured on the coldest expected temperature), it will require a furnace with at least 100,000 BTU capacity to heat the home.

When air-conditioning a home, the term heat gain or cooling load is used to specify the amount of heat that must be removed from the home. A home having a summer heat gain of 36,000 BTU (figured on the hottest typical day) would require an air conditioner rated at 36,000 BTU. This cooling capacity is easily accomplished with a moderate-sized central air-conditioning unit, or several smaller window-mounted units totaling 36,000 BTU.

Larger air conditioners are normally measured in tons of refrigeration, which has nothing to do with the air conditioner's actual weight. In this system, one ton of cooling capacity corresponds to 12,000 BTU. Thus, a 36,000 BTU air conditioner could also be rated as a 3-ton air conditioner. This unit came about in the early "icebox" days of refrigeration because it represented the amount of heat energy required to melt one ton of ice in 24 hours.

Since the BTU and the watt-hour are both units of heat energy, there is a simple conversion factor that can be used to relate them. One watt-hour is roughly 3.4 BTU. Similarly, one kilowatt-hour is about 3,400 BTU.

Electrical energy is sometimes confusing because it is not measured in a unit or quantity that one can see. Electrical appliances are rated in watts which is an indication of the power they consume. Power and energy are not the same things. The electric meter records energy consumption in watt-hours or kilowatt-hours. (The prefix kilo means 1000, so a kilowatt is 1000 watts). In other words, energy is equal to the product of power and time. If one burns a 100-watt light bulb for one hour, one will have consumed 100 watt-hours of electrical energy. If a person burns the same bulb for two hours, it would have consumed 200 watt-hours, or 0.2 kilowatt-hours. If the electric power company charges 5 cents per kilowatt-hour, then 0.2 KWH would cost 0.2 x 5 = 1 cent.

The British thermal unit (BTU) is the basic unit used in measuring heat energy. The energy capacity of both heating and

cooling equipment is measured with this unit. For example, a moderate-sized home in one of the northern states might have a furnace rated at 100,000 BTU and a central air conditioner rated at 36,000 BTU. The furnace is rated on the basis of how much heat it can deliver to the house, while the air conditioner is rated by how much heat it can remove from the house. As these figures indicate, one BTU represents a fairly small amount of heat energy. Technically speaking, a BTU is the amount of heat required to raise the temperature of one pound of water by one degree Fahrenheit. However, it is easier to visualize by thinking of a BTU as being about equal to the heat delivered in one hour by the flame of one candle on a birthday cake. To convert watt-hours to BTU, simply multiply the number of watts by 3.4. Alternatively, to convert BTU to watt-hours, divide the BTU rating by 3.4. Electrical heating equipment is sometimes sized in watt-hours instead of BTU. This is particularly the case with baseboard heaters and space heaters.

The energy efficiency ratio (EER) is a handy way of comparing the efficiencies of various air conditioners. The EER is equal to the BTU rating divided by the input watts. Air conditioners do not produce heat directly, instead they merely transfer or pump heat energy from one place to another. In a refrigerator, for instance, the motor pumps Freon gas through coils located on the inside and outside of the refrigerator. One coil absorbs and removes heat energy from the inside, making it cold, while the second coil dissipates the heat into the

outside air circulating over its fins. The advantage here is that it takes less energy to pump heat around than it does to generate it, as in a heater. This is proven by the fact that typical conditioners have an EER between 5 and 10 and that a typical air conditioner is capable of removing about 5 times as much heat energy from the home as the unit itself consumes in electrical energy.

The EER for an air conditioner is determined under prescribed test conditions of temperature and humidity, and this is done so that one can easily compare the performance of all air conditioners. But it must be pointed out that temperatures will vary in actual operation and so will the efficiency with which an air conditioner can pump heat out of the house. The official EER rating reflects a typical summers operating condition; however, one can expect that an air conditioner will use more electrical energy on really hot days and less on cool days.

HEATING, VENTILATING, AND AIR CONDITIONING
CONSERVATION

UNIT I: FUNDAMENTALS OF HEATING AND
COOLING

ACTIVITY

Directions: Discuss the meaning of these terms:

A. Watt

B. Kilowatt

C. British Thermal Unit

D. Heat Load

E. Heat Gain

F. Cooling Load

G. Tons of Refrigeration

H. Energy Efficiency Ratio

I. Temperature Difference

J. Inside Temperature

K. Relative Humidity

L. Humidifier

M. Dehumidifier

N. Ventilation

O. Infiltration

UNIT I: FUNDAMENTALS OF HEATING AND COOLING

HANDOUT 3: TEMPERATURE DIFFERENCES

Temperatures are generally measured in degrees Fahrenheit in the U.S. although the metric Celcius (or centigrade) scale, used almost everywhere else in the world, is catching up with us. On the Celcius scale, 100° (212°F) represents the boiling point of water. In terms of room temperature, 20°C (68°F) is just a bit on the chilly side, while 25°C (77°F) is just a bit on the warm side. Throughout this book temperatures will be given in Fahrenheit unless otherwise noted.

The temperature difference is the difference between the inside and outside temperatures of a building. As the temperature difference increases, the heat load or cooling load also increases. Consequently, it will take more fuel to heat a house when the difference between the inside and outside temperatures is 70 degrees than when the temperature difference is only 30 degrees.

Design temperatures vary according to location in the nation. The winter design temperature tells how cold it will get in an area. It will determine the heat load of the home and, therefore, the size of the required heating unit. For example, the winter design temperature in Milwaukee, Wisconsin,

is -17°F. The temperature difference for a home in Milwaukee with its thermostat set at 63°F would then be 85 degrees. Similarly, the winter design temperature in Jacksonville, Florida, is 33°F, so for the same thermostat setting, the Milwaukee home would require a much larger heating unit than an idential home in Jacksonville.

The following is a sample of design temperature for heating:

KANSAS	
Atchinson	-10
Concordia	-10
Dodge City	-10
Iola	- 6
Leavenworth	-10
Salina	-10
Topeka	-10
Wichita	- 6

Summer design temperatures also vary according to location. The summer design temperature tells how hot it is expected to get in the summer. In Milwaukee the summer design temperature is 95°F, while in Jacksonville it is 104°F. The air conditioners used in these areas must be sized according to the summer design temperatures.

The following figures show the design temperature for cooling:

State & City	Dry Bulb	Wet Bulb
KANSAS		
Atchinson	100	78
Concordia	95	77
Dodge City	95	78
Iola	100	75
Leavenworth	100	76
Salina	100	78
Topeka	100	78
Wichita	100	75

The inside temperature in a home is regulated by using heating and cooling equipment. However, the inside temperature also affects the temperature difference between the inside and outside of the house. Thus the setting of the thermostat changes the heating and cooling load of the home. Lowering the thermostat in the winter lowers the heat load of the home, meaning that less energy is consumed by the furnace in maintaining the home at the desired temperature. Raising the inside temperature of the home during the summer means that the cooling load is reduced and the air conditioner doesn't have to work as hard.

A point to remember is that the heating and cooling loads for a home will not be the same because different temperatures are involved. A house with a heat load of 80,000 BTU will not have a cooling load of 80,000 BTU except possibly in some southern states. In a typical northern state, the house might

have an 80,000 BTU heat load and a 36,000 BTU cooling load. The difference in heating and cooling loads results because the loads are figured using different design temperatures and inside temperatures, and also because they include solar heating effects due to sunlight. The heating and cooling loads in areas can be found for almost any structure by using charts and tables designed for that very purpose.

The heating and cooling loads, and hence fuel bills, are also affected by what is inside the building. Appliances such as stoves, toasters, irons, ovens, washers, and dryers produce heat. Lamps, in addition to giving light, also contribute heat. People, whether sitting or actively moving about, also generate varying amounts of body heat. In the winter this extra heat is welcomed because it lowers the heating load, but in the summer this extra heat places an added burden on the air-conditioning system that must remove it.

UNIT I: FUNDAMENTALS OF HEATING AND COOLING

HANDOUT 4: HUMIDITY

Humidity refers to the amount of water vapor or moisture in the air. Warm air can hold more water vapor than cool air, so warm air speeds up evaporation. Relative humidity is a way of expressing the percentage of moisture contained in the air at a specific temperature. For example, 50% relative humidity means that the air is holding only half as much moisture as it is capable of holding at that temperature. Raising or lowering the temperature will change the relative humidity. In a sealed house, as the temperature rises, the relative humidity decreases; and as the temperature falls, the relative humidity increases. If the temperature falls enough, as when the air circulates over a cold beverage glass, the relative humidity reaches 100% and water begins to condense out of the air, forming drops of water on the glass.

High humidity and condensation can be very bad in a home, making the air feel clammy, rotting window moldings, and rusting tools and equipment. On the other hand, too little humidity makes the air feel dry, increases static electricity, and causes wood to dry and shrink. Consequently, both humidifiers and dehumidifiers are often used in homes to control the

relative humidity to within confortable limits.

Since air conditioners also dehumidify the air by condensing and removing water vapor, it is desirable to select a unit with the right cooling capacity so that it will properly control both the humidity and temperature of the home. (Refer to UNIT II for a discussion of relative humidity, wet bulb temperatures, dry bulb temperatures, and human comfort zones.)

The motion of the air in a home plays many important roles. Too much air motion can make a home feel drafty, while too little air motion prevents a uniform heating and cooling of the air. Air coming into the house from outside, and the subsequent loss of air from inside, is also a major source of heat loss and heat gain. Sometimes this outside air is desirable, sometimes it is not. Fresh air can supply oxygen and remove stale odors, but most homes ordinarily have enough air entering through the opening and closing of doors that no additional air is needed. In general, the air movement into and out of a home can occur in two different ways: ventilation and infiltration.

Ventilation occurs when air is intentionally brought into the home and made to mix with the air in the building. Ventilation air can be brought into the home with a separate fan, or it can be introduced using a special vent connected in the duct system. In either case, it is necessary to control the amount of outside air brought in as well as its temperature.

Many buildings are required by law or local building codes to have a certain amount of outside ventilation air, especially,

nursing homes, hospitals, factories, and office buildings. The purpose of this ventilation air is to mix fresh air with the circulating air in order to reduce the amount of odors, bacteria, and noxious gases. The ventilation air also insures that an acceptable level of oxygen is present in the air.

The average home, though, does not need to have outside air brought into it. The attic and crawl space, however, do need ventilation. The attic space usually needs ventilation all year round to remove heat buildup in the summer and moisture in the winter. The crawl space needs venting in the summer to remove moisture that would rot beams and produce musty odors. Such ventilation is not usually desirable in the winter because it increases the heat load of the home and results in cold floors.

Ventilation in the furnace room is sometimes required by insurance and loan companies. This requirement is intended to prevent the furnace from burning up all the oxygen in the house. The furnace room is thus equipped with an outside vent to provide fresh air to the furnace burners, and the combustion gases are then exhausted safely up the chimney. In many European countries, the vent is opened and closed automatically to increase furnace efficiency, but at present this scheme is not approved in the U. S.

Infiltration air enters the home through cracks around windows and through tiny openings in the walls, ceilings, and

floors. Hearing whistling noises around doors and windows while the wind is blowing hard is listening to infiltration air. The same is true when window shades and blinds move as the wind blows outside. This infiltration air is not intentional-- a perfectly sealed home would not have any. Since infiltration air must be heated and cooled, it contributes to the heating and cooling load of the home.

Heat energy is moved or transferred from one place to another by three major methods: convection, conduction, and radiation.

SUMMARY

By applying this information, the homeowner becomes aware of how his or her home is conditioned year round. It takes a balance of factors in home conditioning to produce the most efficient system for the energy used.

HEATING, VENTILATING, AND AIR CONDITIONING CONSERVATION

UNIT II: HEATING SYSTEMS

UNIT OBJECTIVES

Upon the completion of this unit the student will be able to:

1. Identify the compononts of a forced air heating system.
2. Calculate heat loss in a home.
3. Size a heating system for a particular home heating need.
4. Explain the difference in fuel costs among energy fuels available for heating use.
5. Recognize and implement measures to improve energy efficiency in heating systems.
6. Discuss differences in efficiency among gas, oil, electric, and heat pump central systems, and baseboard and space heaters.
7. Discuss maintenance measures for heating systems.
8. Discuss the role of humidifiers in heating a home.

HEATING, VENTILATING, AND AIR CONDITIONING CONSERVATION

UNIT II: HEATING SYSTEMS

HANDOUT 1: INTRODUCTION TO HEATING SYSTEMS AND COMPONENTS

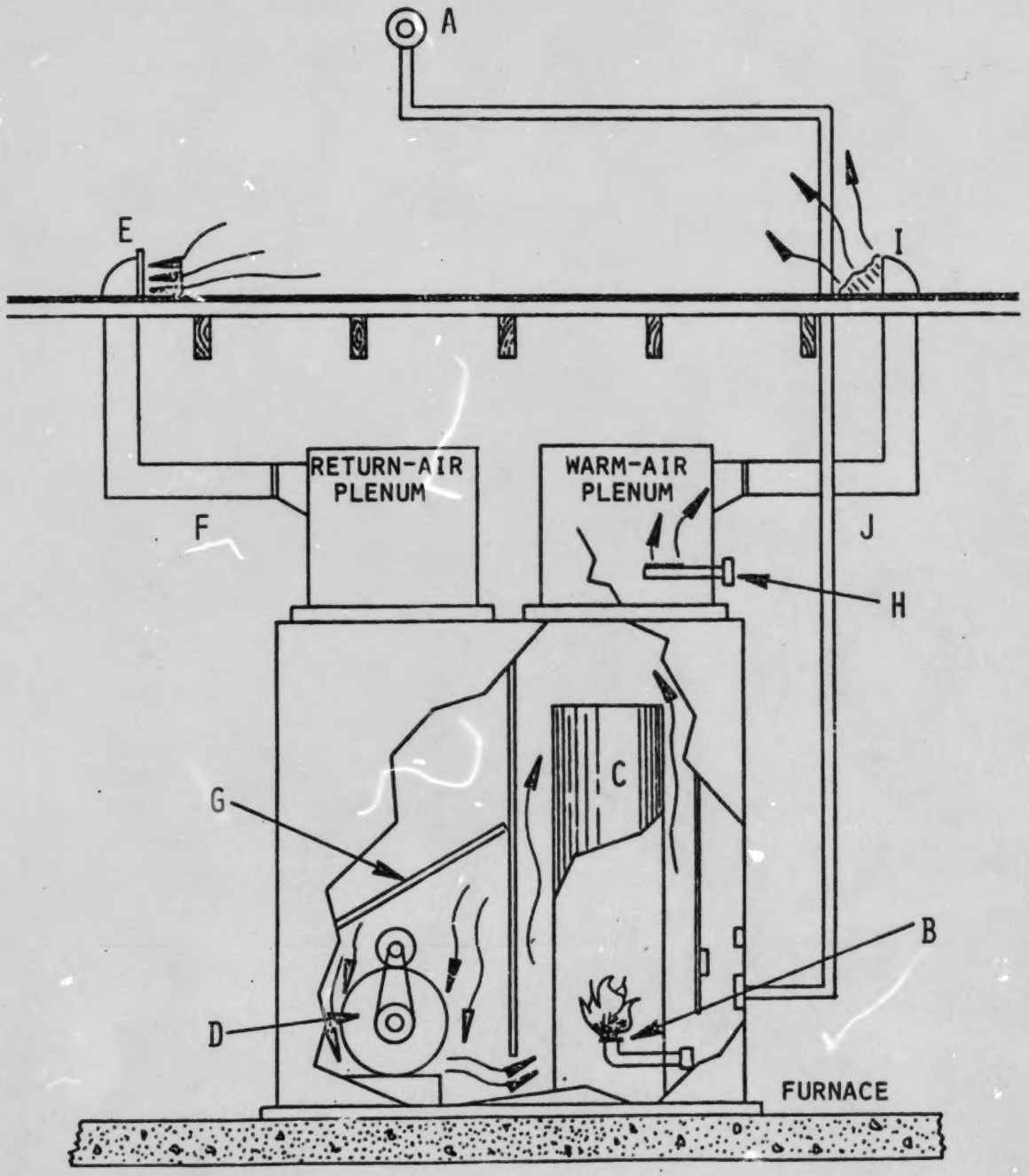
Unless a heating system is operating at maximum efficiency, money is lost. Any time a furnace is out of adjustment or the air circulation is restricted, the heating efficiency is reduced and the operating cost is increased. Once it is understood how a heating system works and how to size a unit for a particular need, it will be easy to correct and even anticipate common problems that affect heating system efficiency.

FORCED AIR HEATING COMPONENTS

A central heating system consists of a furnace which serves as the source of heat, a fan to distribute the heated air, and ductwork to provide a path by which the air travels. The illustration on the following page shows how a forced air system operates in principle.

All forced air systems operate similarly...and automatically. When room temperature drops below a pre-determined minimum setting of the thermostat (A) the burner (B) starts

HEATING SYSTEM



and heats the air around the heat exchanger (C) in the furnace. When the temperature of the air in the furnace reaches the "fan on" setting of the fan control, the furnace blower (D) starts. The blower pulls the cool air from the rooms through the grilles (E) and return-air ducts (F) to the furnace. Here, the air passes through the filters (G) and circulates around the heat exchanger where it warms and picks up moisture from the humidifier (H). The cleaned, moistened and warmed air is then delivered to the registers (I) in each room through the warm-air ductwork (J). When the thermostat is satisfied, the burner automatically shuts off. The fan control should be set so that the blower runs almost continuously during cold weather. Cost of continuous blower operation is little more than for intermittent operation, and gives more comfortable, uniform heating with little chance of air stratification. A little control automatically cuts out burner if furnace overheats.

HEATING, VENTILATING, AND AIR CONDITIONING CONSERVATION

UNIT II: HEATING SYSTEMS

HANDOUT 2: TYPES OF HEATING SYSTEMS

FUEL FURNACE

Fuel furnaces must have flues to expel the combustion fumes, and unfortunately carry away large amounts of heat energy. Wood-burning units have the lowest efficiency rating--as much as 70% of the heat produced from burning wood is wasted as it goes up the flue. Coal furnaces are almost as bad.

Therefore the damper that controls the flue has a lot to do with the efficiency of the heating system. Ideally, a fuel-burning furnace needs only enough air to assure that all of the fuel is cleanly burned. Not enough air will prevent the fuel from burning completely, producing soot and dangerous carbon-monoxide fumes. Too much air, on the other hand, only cools the combustion temperatures and carries more heat up the flue. Hand-fed heating systems are, therefore, very inefficient because the damper setting must also be controlled by hand, reducing the efficiency to about 30%. If an automatic feeder and automatic damper are added, however, the efficiency of these units can be increased

to about 50%.

Natural gas, propane, butane, and oil furnaces have efficiency ratings of about 80%. If the gross input BTU to a furnace is listed as 100,000 BTU one would expect the net figure given as 80,000 BTU. But in practice, one could achieve a slightly higher net heating capacity with a finely tuned furnace--and a lot lower output with a poorly tuned one.

The higher efficiencies of gas and oil furnaces are due primarily to their construction. The amount of fuel fed into the furnace is carefully and automatically controlled when properly adjusted. The heat exchanger in such furnaces is also constructed to extract the maximum amount of heat energy from the hot gases produced as the fuel burns. Finally, the air flow through the combustion chamber is regulated by dampers to insure good combustion of the fuel. However, if the furnace is not properly adjusted and cleaned for maximum heat transfer, one cannot expect to obtain good heating efficiency.

If the air flow to the burner of a gas or oil furnace is not correct, the efficiency can drop to less than 50%. The flame of a gas furnace should be a bright blue color. If it is yellowish in color, the air flow could be adjusted

too low or it may be that the gas pressure is too high; if the flame is erratic or jumps off the burner, the air flow may be adjusted too high or the gas pressure may be incorrect. When the adjustments are not correct on an oil-burning furnace, the flame smokes, causing problems with soot build-up in the flue or chimney.

Air flow through the heat exchanger in a furnace is also quite important. If the heating ducts or cold air returns are too small, the furnace will not deliver its rated heat capacity. A safety thermostat on the heat duct leaving the furnace prevents the air temperature from exceeding safe levels. If the temperature rises too high, the high-temperature-limit thermostat turns off the burners until the air temperature drops to a safe level again. If the burners on the furnace turn on and off even though the room thermostat is demanding more heat, that means the limit thermostat is operating, and this in turn indicates that there is probably not enough air flow through the ductwork.

Every forced-air furnace has air filters in the cold air intake to prevent dust particles from collecting in the furnace and ductwork. If dust collects in the burner box, it not only decreases heat conduction to the air, it also poses a fire hazard. If one smells scorched air from the heat registers, it is likely some dust has gotten into the burner box. A

clean air filter will assure maximum air flow through the furnace.

The actual efficiency of a heating system will depend on several factors:

1. Properly adjusted burners.
2. Clean nozzles and jets.
3. Correct fuel pressure at the nozzles and jets.
4. Clean fuel filters.
5. Clean air filters.
6. Properly adjusted nozzle and jet openings.
7. Correct size supply and return air ducts.
8. Well lubricated furnace blower.
9. Automatic (rather than manual) furnace operation.

If any of these factors are out of line, the efficiency of the system will drop, wasting both fuel and money.

HEAT PUMPS

A heat pump is the most efficient type of mechanical heating system. A heat pump does not have to burn fuel to produce heat, and it does not have to waste electrical energy by running it through a resistive wire element to produce heat. The heat pump only requires enough electricity to run a compressor motor, which takes the heat out of the air on the outside of the house and deposits this heat inside the house.

The heat pump is actually a kind of refrigeration or air-conditioning system that can work in reverse. In the summer, the heat pump cools the house in the usual manner, removing heat from within the house and depositing it outside. In the winter, the heat pump works in reverse, removing heat from the outside and depositing it inside.

The efficiency of a heat pump is measured in terms of how much easier it is to pump heat energy than to generate it by conventional means. When used to heat a house, the efficiency of a heat pump depends primarily on how cold it is inside. As the temperature drops, the efficiency also drops. If it gets too cold outside, the heat pump automatically switches on an electric heating element, when it becomes easier and more economical to generate heat energy that way. Normally, though, as long as the outside temperature is above about 20°F, the heat pump can heat the house more cheaply than an electric furnace. As the outside temperature approaches the inside room temperature, the efficiency continues to climb dramatically.

Taken on a year-around basis, a heat pump can usually heat a house for a third or half the cost of conventional electric heat. In a northern city like Cleveland, Ohio, for example, the annual heating cost for a heat pump is about 50% of that for an ordinary electric furnace, making the heat

pump cost-competitive with natural gas in that area. In southern states, operating efficiency is much higher because outside temperatures are higher.

ELECTRIC FURNACES

Electric furnaces resemble fuel furnaces but differ because no combustion takes place. As a result, there are no burner adjustments to make and no flue pipe to waste heat. An electric furnace, therefore, requires little maintenance to keep the unit operating at maximum efficiency of 90--100%.

Electric furnaces, however, have much in common with fuel furnaces when it comes to the ductwork and blower that circulates the heated air throughout the house. For this reason, most of what has been said about the size of the ducts, clean air filters, and routine maintenance also applies to electric furnaces.

Because of the relatively high cost of electricity as compared to other fuels, the efficiency of an electric furnace system is of paramount concern. Heat losses cannot be tolerated, and every step must be taken to thoroughly insulate and seal the home. Most of the heat loss occurs in the duct system, so it is important to properly insulate and seal ducts passing through garage areas and open crawl spaces. Most all-electric homes are built with considerably more insulation than

other homes to offset the higher cost of electricity, so adding more insulation to the house is usually a good idea.

SPACE HEATERS

For a small house or apartment in areas with mild winters, a heating unit such as a wood stove, coal stove, fireplace, gas heater, oil heater, propane heater, or electric space heater can be more economical than a central furnace.

When choosing a space heater, keep safety and energy use in mind. Electric heaters should be considered last because they are heavy users of energy. Non-electric heaters should be properly vented. If venting is inadequate or the adjustments faulty, deadly quantities of carbon monoxide may be produced. Many states prohibit unvented units because of this hazard.

A space heater should have a guard around the flames or coils to protect children, pets, and clothing from the heat source. Allow adequate clearance on all sides of the unit.

To keep the heater in good working order, inspect it regularly for needed adjustments, cleanliness, cracks, faulty legs, and hinges. Keep the electrical wiring in good condition.

<u>For Safe Operation of Space Heaters-</u>

-Keep a window partially open if an unvented unit must be used. Fresh air will prevent the accumulation of gas fumes.

-Use only the fuel the heater is designed for. Do not

convert to another fuel without consulting an expert.

-Keep children away from space heaters and stoves.

-Be certain the fire has proper ventilation to maintain a constant rate of burning that gives moderate heat, not too hot or too cool.

-Always keep a screen around a heater that has open flames.

-Keep the damper open while the fuel is burning. This will provide for efficient burning and will prevent accumulation of explosive gases.

-Learn how to light a gas heater properly. If someone smells gas, turn off all controls and open a window. Don't allow gas to accumulate. If heater fails to light on the first try, allow sufficient time for the gas to dissipate before trying again.

-Never keep flammable liquids around heaters. Vapors can be ignited by the open flames.

-Use heavy-duty cord for electric heaters. Have an electrician check the wiring if a heater uses higher than usual wattage.

-Never place an electric heater near a bathtub, shower, or sink. Don't touch one when wet.

-Place a metal sheet under the unit to protect the floor from live coals, burning or overheating.

The fireplace is used today primarily as an enjoyable addition to a house. Watching the flames can bring peace to the heart and soothe the soul. Even more importantly, however, the fireplace can be used to supplement central heating. On cool days, the fireplace might provide the necessary heat to take away the chill.

The most energy-efficient fireplace will have warm air vents through which hot air can be spread around the room or through ducts to other rooms. A modified fireplace with a fan can also help circulate hot air effectively.

To obtain maximum efficiency from a fireplace, be sure the chimney is working as it should. If the chimney is too low, the draft will not be strong enough to pull out the smoke. Keep the chimney clear of ashes and be sure the flue is operating properly.

UNIT II: HEATING SYSTEMS

ACTIVITY

Check the effects on efficiency by changing flow rates. This can be done by partially blocking a return air duct or partially blocking or shutting the vents on a heat duct. In this case the student should have the system clean and open and do a temperature versus time measurement on the heating of a room with the vents open and partially closed or blocked completely. When a student has part of the return duct closed, a timing should be done on how long it takes the furnace system to cycle on and off and how often it comes back on. These experiments will show how much less the efficiency and cycle time is for a furnace which has lower reduced rates of flow or which is partly blocked. In addition, filters are very important to the intake of the furnace. Dust in a fine layer is a very good insulating material. If one lets dust build up inside the pipes he/she is essentially blocking the inside of the pipes and the heat exchanger. Dust in the outer pipes may be slightly insulative but it usually is deposited in the furnace first and will reduce the plenum's efficiency or heat

transfer. Also, the fine dust increases the amount of cleaning, the amount of traffic, and the amount of dirt that is in the air.

HEATING, VENTILATING, AND AIR CONDITIONING
CONSERVATION

UNIT II: HEATING SYSTEMS

HANDOUT 3: SIZING A HEAT SYSTEM

Once a house is designed to include insulation, types and sizes of windows, size and shape of house, orientation, the homeowner must determine the heat loss and heat gain requirements of the home.

The most important point to be stressed in sizing and designing a heating system for a particular home is to install equipment that is no larger than required. This concept is relatively new and has gained impetus since the oil embargo of 1973 and the increasing fuel costs. It is not uncommon for buildings built prior to 1974 to have heating systems and circulation fans designed three times larger than the heating requirements. In addition to more energy consumption, oversized equipment results in short periods of operation, poor comfort conditions, and lower seasonal efficiency.

Ideally, output capacity of heating equipment should not be less than the calculated heating load. And, it should not exceed the calculated heat load by more than 15 percent. Cooling equipment output capacity should be no less than five percent below the calculated cooling load nor more than 12

percent in excess of the calculated cooling load.

Many times, however, it is not possible to obtain equipment within these limitations. If this is the case then the homeowner should consider the possibility of reducing the heat loss and heat gain of the structure to the point where properly sized equipment can be obtained. There are many ways to do this, such as: installing storm windows, increasing the amount of insulation, reducing the heating load by adding earth berms, etc.

Final selection of heating equipment depends upon the type of system selected, the selection of the system in the structure and upon the type of equipment itself.

Sizing a heating system means selecting a furnace and piping large enough to replace the natural loss of heat from the home. To do this properly means knowing some details about the house and local weather conditions.

Each house must be surveyed individually, because its size construction is different from any other house. Houses lose heat through exposed ceilings and floors, outer walls, windows and doors. Heat is lost through each of these areas at a different rate because of sizes, types of materials and use of insulation or storm sash.

All factors are reduced to a common measurement of heat--the BTU (British Thermal Unit). This makes it easy to match

a proper size furnace or boiler (outputs expressed in BTUs) with the heat loss of any house (also expressed in BTUs).

Each geographical location has a design temperature for heating. This is not the lowest temperature recorded, but the lowest temperature reached during 97½% of the time--the only practical approach in designing heating systems. The chart gives the design temperature for heating in selected Kansas cities.

STATE and City	Design Temp°F
KANSAS	
Dodge City	3
Goodland	-2
Topeka	3
Wichita	5

All the information needed for sizing a furnace or boiler can be entered on the work sheet: (Heating Estimate Work Sheet). Much of this information is found just by looking at the house from the outside. This includes type of house and construction, number of windows and doors and use of storm sash.

HEATING, VENTILATING, AND AIR CONDITIONING
CONSERVATION

UNIT II: HEATING SYSTEMS

HANDOUT 4: FUEL COSTS

Once the heat load of a home has been established and the size designed, the type of heating system to install must be determined. This question is predicted on the type of fuel available in a particular area and the fuel costs for operation.

All energy sources are bought in units, such as the gallon, the cubic foot, or the kilowatt-hour. The cost per unit does not tell what it actually costs to heat the house. To figure this one must know how much heat energy one can get from one unit of each energy source. That is, how many BTUs are produced from each unit bought. This information is given on the following page.

Be checking with local fuel suppliers to find out the price of one unit of each type of fuel. Estimate your approximate fuel consumption for a typical winter heating month; then ask the fuel supplier what the cost would be so you can figure the average cost per unit.

COMMON FUELS AND THEIR HEAT ENERGY PER UNIT

FUEL	UNIT	BTU PER UNIT
natural gas	cubic foot	1,000
	therm (100 cu ft)	100,000
propane	gallon	90,000
butane	gallon	130,000
No. 1 fuel oil	gallon	136,000
No. 2 fuel oil	gallon	140,000
electricity	kilowatt-hour	3,413

Note: Propane and butane are gases that become liquids when they are pressurized, so they are sold by the gallon. Liquid petroleum gas (LPG) is a name commonly applied to both propane and butane, or even a blend of the two. In general, propane is used in the north while butane is used in the south.

Fuel costs can then be estimated by using the following formula:

$$C = \frac{F \times E}{P}$$

Where

C = cost per BTU of heat energy, in BTU per dollar

F = BTU value of fuel

E = efficiency of your heating system in percent

P = price of fuel, in cents per unit

To illustrate how this formula is used, let us consider a house with an electric furnace having an efficiency of 90%, and located in a city where the utility company charges 2.5 cents per kilowatt-hour. Putting these numbers into the formula, we get:

$$C = \frac{3413 \times 90}{2.5} = 122{,}868 \text{ BTU per dollar}$$

As another example, let us consider a house with an oil furnace having an 80% efficiency and located in an area where No. 2 fuel oil costs 40 cents per gallon. In this case, the formula tells us that the cost is:

$$C = \frac{140{,}000 \times 80}{40} = 280{,}000 \text{ BTU per dollar}$$

The fuel costs in these two examples do not tell the whole story. You would also have to weigh the cost of installing the particular heating system and any additional insulation you might add to your house. Then there is the question of what fuels are available in your area. So you can see there are actually many factors to consider.

The cost of the heat energy can give you a pretty good idea as to what fuels and heating systems would be more economical in your area. Just the number of BTU per dollar can tell you a lot. You could also estimate the heating bill by

determining the heat load of a particular house for the average temperature difference during the winter heating season. Since the heat load is in BTU per hour, you would have to include the number of hours in each billing period.

HEATING, VENTILATING, AND AIR CONDITIONING
CONSERVATION

UNIT II: HEATING SYSTEMS

HANDOUT 5: MAINTENANCE

FILTERS

All central heating systems have filter. These filters all get dirty--that is the filter's job! They take the dust and lint particles out of the circulating air so dirt does not clog up the working parts of the furnace. The air filter is usually located in the return air duct where the cool air enters the furnace to be heated. As the filter removes the dirt from the air, the filter itself becomes clogged and restricts the air flow, cutting down on both the efficiency and capacity of the firnace. Filters should be checked every month and either be cleaned or replaced.

FANS

The fan most used in heating systems is the squirrel cage fan. This fan circulates the air through the furnace and duct system. Over a period of time, even with regular filter replacements, the blades and motor of the fan will become covered with dirt, reducing air flow in the furnace.

Clean the fan blades with a brush and soapy water. Be careful not to move any of the balance weights from the fan blades.

ADJUSTING LPG AND NATURAL GAS FURNACES

A gas furnace may burn natural gas (methane), propane gas, or butane gas. Natural gas is delivered to the house through underground gas lines, whele liquid petroleum gas (LPG) is stored near the house in supply tanks with direct feed lines to the furnace. The gas flow to the furnace is regulated by a gas valve in the line, which meters the amount of gas entering the burners within the heat exchanger. Air is mixed with the gas there and is ignited to produce heat.

To get the highest amount of heat energy from the furnace, the gas and air mixture must be just right. To accomplish this feat, a series of regulators control the flow of gas to each burner, and each burner has an adjustment mechanism to control the air flow.

Gas Valves

The manifold is a pipe that connects between the gas valve and the burners. Gas flows from the valve into the manifold, which distributes the gas to the burners. The purpose of the gas valve is to control the flow of gas into the manifold. When the thermostat calls for heat, an electrical solenoid in the gas valve opens, permitting gas to flow through the valve

into the manifold.

If the pilot light goes out, the gas valve is shut off to safely prevent gas from escaping into the furnace room and house. The gas valve closes when the pilot light goes out because the thermocouple, a temperature-sensing device, is no longer heated by the pilot light.

If the gas valve leaks, gas can enter the furnace and room even when the pilot light is off. This not only wastes gas and money, it can also be very dangerous, leading to fire or explosion. Therefore, check for gas valve leaks.

Adjusting the Air Mixture

The flame should be a bright blue color close to the burner. If the flame is not burning correctly, the first place to check is the air adjustment. When there is not enough air, the flame will usually have a yellowish color. This means the flame is not burning hotly, so it will take more gas than it should to heat an area. Too much air causes the flame to burn with a pale blue or white color.

Cleaning the Burners

If the air flow is out of adjustment on the burners for a long time, soot may collect around the burners. The flame may even burn inside the burner body or at the gas jet opening and build up carbon and soot inside the burner. Sometimes

dust and lint in the air will also collect in the throat of the burner and partially block the air flow. In damp locations, the burner can become spotted with rust.

Clean the burners with compressed air to remove dirt, lint, and loose soot. If the burners are oily, wipe them carefully with a cloth, but be careful not to bend or break the burners. As a last resort, if there are some really tough buildups of soot, use a cleaning solvent to dissolve the dirt.

Adjusting the Gas Pressure

The gas pressure also affects the mixture of the gas and air going to the burners. If one has tried adjusting the air flow to the burners, has cleaned the burners, is sure that all gas connections are tight, and still has a flame that does not burn properly at the burners, the gas pressure may not be correct. A sure indication of pressure problems is a flame that is too large or too small.

To measure gas pressure, a special gauge is used that measures the pressure in inches of water, indicated by the height of the water column in a glass tube. Gas companies and repair services have them. Do not attempt to adjust the gas pressure without using the proper set of gauges.

Adjusting the Pilot Light

The pilot light in most gas furnaces is on all the time, though some new furnaces use a form of electric ignition.

Before adjusting the pilot light, it is a good idea to inspect it to insure that it is reasonably clean. A dirty or clogged pilot is often responsible for the pilot light going out, and a pilot light that is too small often causes noisy ignition of the burners. To clean the pilot light, remove it from the burner assembly.

Some forms of electric ignition use a hot wire to ignite the pilot, which then heats the thermocouple, which in turn allows the burners to turn on. Oil furnaces generally use arc igniters to light the fuel. Electric ignition systems can save fuel, but they have their problems too. In hot-wire systems, for example, the wire element can fail, but this is easily replaced with a new unit. An advantage of such systems is that the pilot and thermocouple parts are not on most of the time, so they do not have to be cleaned or adjusted as often.

ELECTRIC FURNACES

An electric furnace will usually operate properly and at maximum efficiency for many years without adjustment. Since there is no fuel combustion taking place, there will not be problems with carbon and soot buildup. So any dirt that could decrease efficiency in an electric furnace must come from the air circulated inside the house. Keeping the air filters clean is, therefore, an important part of maintaining an electric furnace. Since there is no combustion, the electric furnace

also has no flue to waste heat energy. As a result, almost all of the heat produced by the furnace elements ends up in the house.

Heat is generated in an electric furnace by passing electric current through resistance wires. When these heating elements raise the temperature of the air enough in the heat chamber, the fan starts and circulates the warm air throughout the house. These electric heating elements draw a lot of electrical power, so it is essential that adequate sized wires are run to the furnace to supply all the current it needs. Normally, the local building codes insure that the proper size wiring is used, since the current passing through these wires also produces heat, which is wasted.

Maintaining the Fan

The fan controls on an electric furnace are usually preset and cannot be adjusted. The switches that turn the fan on and off, for example, are sealed units mounted in the heat chamber. The limit switch is usually a metal fuse (rather than a circuit breaker), and melts when the furnace elements get too hot. Consequently, if the fan does not come on for some reason, the fuse will open, requiring that it be replaced after the fan is fixed.

About all one can do in an electric furnace is to keep the

fan blades, fan motor, and filters clean. If one allows a regular maintenance schedule, there should be few problems with the furnace.

Checking the Thermostat

An electric furnace usually has a special two-state thermostat that prevents waste of energy. For example, consider an electric furnace with four heating elements. When the thermostat calls for heat, the first two elements come on immediately. The second two elements will not turn on unless the thermostat senses a big drop in temperature or unless the last two elements do not heat the house fast enough. This technique gives some energy savings to the homeowner because the second two elements are not used until they are needed.

Sometimes an outside thermostat is also attached to the two-stage thermostat inside the house. In this system, if the temperature outside remains above a preset temperature (usually about 35°F), the second stage of the thermostat cannot come on.

HUMIDIFIERS

Relative humidity is the perventage of moisture in the air relative to the amount of moisture that the air could hold at that temperature. People generally feel uncomfortable when there is too much or too little moisture in the air. During the summer, for example, a relative humidity of more than 70%

makes the air feel damp, close, and sultry. During the winter, a relative humidity of less than 30% makes the air feel dry, irritates the nose and throat, and encourages the buildup of static electricity in rugs, upholstery, and clothing. Dry air also makes the air feel cooler because it speeds up the evaporation of moisture from the body.

During the heating season, it is difficult to maintain a suitable level of humidity because the air outside the home contains very little moisture. For example, if the temperature is 50°F outside with 100% relative humidity, the humidity will drop to less than 20% by the time the air has been heated to 70%F. For outside temperatures below freezing, the air contains practically no moisture to speak of. For this reason, the relative humidity in your home will go way down during the coldest winter months.

Many schemes have been tried for increasing the humidity level in a home during the winter. You can boil pans of water on the stove, hang up wet clothes in the basement to dry, drape wet towels over radiators, set water-filled pans on the floor, etc. But if not inefficient, these methods are messy to say the least. Most modern furnace humidifiers require a minimum of maintenance, and a selection of models is available in a wide price range.

All humidifiers should be inspected once a year before

the heating season begins. Evaporator-type humidifiers should also be inspected a couple of times during the winter to be sure that accumulations of lime and minerals from the evaporating water do not clog the water-inlet valve or the fins, belts, and bristles.

As water is evaporated from the humidifier, lime and mineral deposits are left behind. These collect on the valve seat, so they must be removed periodically. If they are not, the valve may not turn off, causing the water basin to overflow.

To clean the humidifier, first remove it from the bottom of the duct. You can drain the water from the basin of the humidifier through the drain hole in the bottom. Scrape all the mineral deposits from the float, the valve, and the valve seat. Remove the mineral deposits from any other part of the humidifier and water lines.

Humidifier Operation and Maintenance

1. Read the owner's manual.
2. Place the unit near a room partition and allow 6 inches behind it for circulation.
3. Avoid small rooms, heat sources, and corners. The bottom of a stairway is a good location.
4. For the first few days, adjust at high settings to moisten air, walls, and furniture. Turn down as dampness develops.

5. Set humidistat at a level for personal comfort.
6. Disconnect the unit when filling or cleaning the water reservoir. Be sure the area and unit are dry before reconnecting the cord.
7. Do not pour hot water in the reservoir or overfill it.
8. Dust the grilles every week with a soft brush.
9. Every few weeks, empty the reservoir and scrub the inside with a sponge and a mild detergent to prevent mold, mildew, and bacteria.
10. Clean the filter pad monthly.

HUMIDIFIER--FUEL SAVINGS

For years it has been common knowledge that people feel warmer when the humidity in a room is higher. Generally, you can figure that each 10% increase in relative humidity enables you to turn down the room thermostat by about one degree. This would seem to indicate that you can obtain a substantial fuel savings by using a humidifier in your home. But you have to be careful about such claims because the savings are not as great as some manufacturers would have you believe.

You will remember that when water evaporates it absorbs heat energy. Your furnace has to supply this heat energy when you use a humidifier--and it takes over 8000 BTU to evaporate just one gallon of water. Fortunately, however,

the average size home needs less than one gallon of water evaporated into the air to bring the relative humidity from 0% up to 50%. Since there are many other sources or water vapor in your home, your furnace humidifier does not have to supply very much water each day to maintain the humidity at a comfortable level. Of course, this depends upon how much infiltration air enters your home, pushing out the moist air. The more tightly sealed your home is, the more moisture it will be able to retain, and the less water vapor your humidifier will have to add to the air to replace what was lost.

As an example of cost, let us use a home that has an average heat load of 25,000 BTU per hour over a six month heating season. During the average 24 hour day, this furnace would consume 600,000 BTU of heat energy, and assuming that the humidifier used up a whole gallon of water in that time, 8000 BTU of heat energy would be needed to evaporate the water. Now, if having a 50% relative humidity inside the house would permit you to turn down the thermostat just two degrees, the furnace would consume 30,000 BTU less energy on a day that the outside temperature was 40 degrees less than the inside. Clearly, the 8000 BTU expended in evaporating the gallon of water saved you quite a bit of fuel energy. In general, the energy savings will pay for the furnace humidifier in about two to five years, depending on how much moisture you have to add to the air in your home and how expensive the unit was.

HEATING, VENTILATING, AND AIR CONDITIONING
CONSERVATION

UNIT II: HEATING SYSTEMS

HANDOUT 6: ENERGY SAVING TIPS IN HEATING

The U.S. Department of Energy has outlined tips for saving energy in heating. This list serves as a summary of conservation measures available to the homeowner when considering heating the home.

Heating and cooling our homes account for most of our residential energy costs. Do not waste any of that precious conditioned air, whether you pay for it yourself or pay your landlord for it.

<u>During Both Heating And Cooling Seasons</u>

1. Close off unoccupied rooms and shut their heat or air conditioning vents; or turn off room air conditioners. (This does not apply if you have a heat pump system. Leave it alone; shutting vents could harm a heat pump.)
2. Use kitchen, bath, and other ventilating fans sparingly. In just one hour these fans can blow away a houseful of warmed or cooled air. Turn them off just as soon as they have done their job.

3. Keep your fireplace damper closed unless you have a fire going. An open damper in a 48 inch square fireplace can let up to 8 percent of your heat out the chimney.

Heating Energy Savers: do not turn the heat on until you have to. On cool evenings use your fireplace instead and add a blanket at night.

With Heating Equipment

1. If you use electric furnace heating, consider a heat pump system. The heat pump uses thermal energy from outside air for both heating and cooling. Costs for these pumps run from about $2,000 for a whole house unit to about $425 for room size. But they can cut your use of electricity for heating by 30 to 40 percent and also can provide some savings in cooling costs.
2. If you plan to buy a new gas heating system, ask your gas utility or public service commission about the savings potential of electronic ignition. Ask also about possibilities for retrofitting the system you may already own.
3. Consider the advantage of a clock thermostat for your heating system. The clock thermostat will turn the heat down for you automatically at a regular hour before you retire and turn it up again before

you wake. While you can easily turn your thermostat back at night and up again in the morning yourself, the convenience of a clock thermostat may be worth the $70 to $90 cost to you.

4. Consider buying a properly sized furnace that incorporates an automatic flue damper. This device reduces the loss of heat when the furnace is off. (Contact your gas utility or oil supplier for guidance.)
5. Do not use your fireplace for supplemental heating when your furnace is on unless you take one of the measures suggested below to lessen the loss of heated air from the house.

The warmth from a fire on the hearth generally does not radiate through the house; the heat gain is confined to the room with the fireplace. And when your furnace is on, too, a considerable amount of heated air from the rest of the house flows into the fireplace and goes wastefully up the chimney. Then the temperature in other rooms of the house goes down, and the furnace uses more fuel to raise it to the level controlled by the thermostat. So you use more fuel, rather than less, when the furnace and fireplace are both going.

Lessen Heat Loss When You Use Fireplace When Furnace Is On

1. Lower the thermostat setting to 50 to 55 degrees. Some warmed air will still be lost, but the furnace

will not have to use as much fuel to heat the rest of the house to these temperatures as it would to raise the heat to 65 degrees.

2. Close all doors and warm air ducts entering the room with the fireplace and open a window near the fireplace about 1/2 to 1 inch. Air needed by the fire will be provided through the open window and the amount of heated air drawn from the rest of the house will be reduced.
3. If you have a simple open masonry fireplace, consider installing a glass screen. This will cut down on the loss of warmed air through the flue.

When The Heat Is On

1. Lower your thermostat to 65 degrees during the day and 55 degrees at night. You can save about 3 percent on your fuel costs for every degree you reduce the average temperature in your home. In addition, you can save about 1 percent on your heating bills for every degree you dial down only at night.
2. Keep windows near your thermostat tightly closed, otherwise it will keep your furnace working after the rest of the room has reached a comfortable temperature.
3. Have your oil furnace serviced at least once a year,

preferably each summer to take advantage of off-season rates. This simple precaution could save you 10 percent in fuel consumption.

4. Clean or replace the filter in your forced-air heating system each month.
5. Check the duct work for air leaks about once a year if you have a forced-air heating system. To do this, feel around the duct joints for escaping air when the fan is on.
6. Relatively small leaks can be repaired simply by covering holes or cracks with duct tape. More stubborn problems may require caulking as well as taping. You could save almost 9 percent in heating fuel costs this way.
7. If you have oil heat, check to see if the firing rate is correct. Chances are it is not. A recent survey found that 97 percent of the furnaces checked were overfired.
8. If your oil furnace does not run almost constantly on a very cold day, call a service man.
9. Do not let cold air seep into your home through the attic access door. Check the door to make sure it is well insulated and weather-stripped, otherwise you will be wasting fuel to heat that cool air.

10. Dust or vacuum radiator surfaces frequently. Dust and grime impede the flow of heat. And if the radiators need painting, use flat paint, preferably black. It radiates heat better than glossy.
11. Keep draperies and shades open in sunny windows; close them at night.
12. For comfort in cooler indoor temperatures, use the best insulation of all--warm clothing.

Dressing Wisely Can Help You Retain Natural Heat

1. Wear closely woven fabrics. They add at least a half degree in warmth.
2. For women, slacks are at least a degree warmer than skirts.
3. For men and women, a light, long-sleeved sweater equals almost 2 degrees in added warmth; a heavy long-sleeved sweater adds about 3.7 degrees; and two lightweight sweaters add about 5 degrees in warmth because the air between them serves as insulation to keep in more body heat.

If every household in the United States lowered its average heating temperatures 6 degrees over a 24 hour period, we would save more than 570,000 barrels of oil per day or more than 3.5 percent of our current oil imports.

HEATING, VENTILATING, AND AIR CONDITIONING
CONSERVATION

UNIT III: COOLING SYSTEMS

UNIT OBJECTIVES

Upon completion of this unit the student will be able to:

1. Identify the components of a typical air conditioner.
2. Distinguish between the uses of room air conditioners and central air conditioning systems.
3. Calculate and size an air conditioner for a particular cooling need.
4. Discuss maintenance and use tips for efficient air conditioning performance.
5. Discuss the role of dehumidifiers in summer cooling.

HEATING, VENTILATING, AND AIR CONDITIONING
CONSERVATION

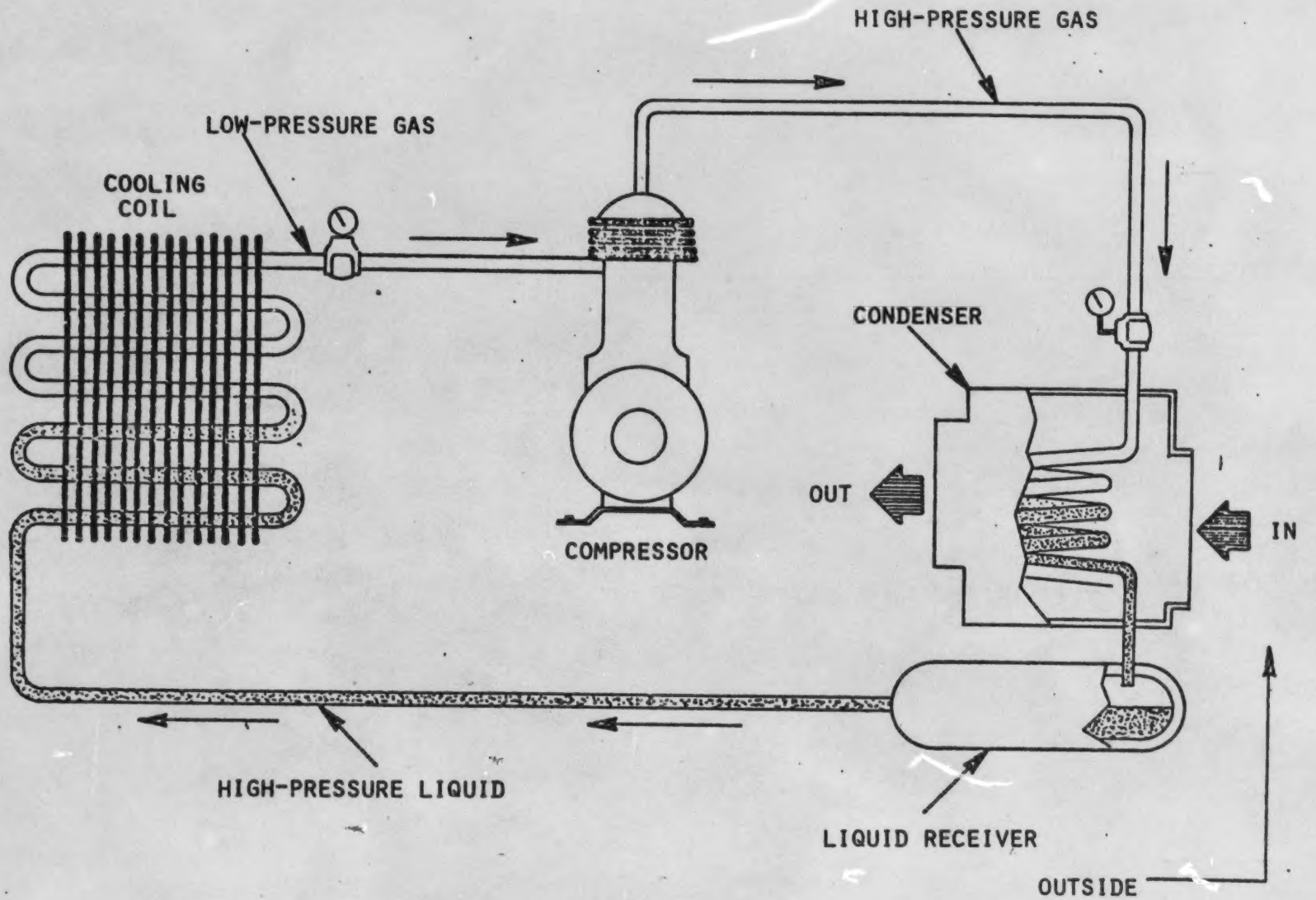
UNIT III: COOLING SYSTEMS

HANDOUT 1: INTRODUCTION

There are several types of air conditioning systems for cooling the home during the hot summer months: a wide range of air conditioners, central air conditioners, or heat pumps. All of these systems work in essentially the same way, and all require similar maintenance to keep them working at top efficiency.

Most homes built today have the capability of easy conversion to central air conditioning, if they do not already have it. Homes built with heat pumps to provide heat during the winter also use the same unit to provide air conditioning during the summer. Most room air conditioners are used today where only one or two rooms are to be cooled, or where central air conditioning is impractical or unnecessary. So the type of air conditioning one has or wants depends on the cooling needs and the cost of installing a particular system.

AIR CONDITIONING SYSTEM



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HEATING, VENTILATING, AND AIR CONDITIONING
CONSERVATION

UNIT III: COOLING SYSTEMS

HANDOUT 2: COMPONENTS OF THE AIR CONDITIONING SYSTEM

An air conditioner cools air much as a refrigerator cools the air inside it. The principal difference is that an air conditioner is designed to have the cooled air blown through the cooling coil and out (through whatever distribution system is used) into the house then back (through return-air system) to the coil for re-cooling. While cooling the air, the coil condenses the moisture carried by the air, and the resulting water runs off through a water line to leave the air less humid.

Whatever type the air conditioner, it has the functional parts illustrated on the following page. A blower-coil or a self-contained unit has, in addition, an electric-motor-driven blower to circulate house air through the cooling coil. The refrigerant, which circulates around from the cooling coil to the compressor to the condenser and back to the coil, is a volatile liquid (such as Freon) which changes from gas to liquid and back to gas as the pressure and temperature to which it is subjected changes.

Gas (at low pressure) moves from the coil to the compressor, where it is compressed and forced on to the condenser

in the form of a hot gas or vapor. Here the hot gas is cooled (by outside air) and becomes a liquid. This liquid, still under pressure, travels to the cooling coil where it is allowed to expand (pressure is relieved) into a gas again. While expanding it absorbs heat to keep the coil relatively cold and thereby cools the house-air blown through this coil. A thermostat can be used to control compressor operation and/or blower operation to maintain desired house-air cooling.

HEATING, VENTILATING, AND AIR CONDITIONING
CONSERVATION

UNIT III: COOLING SYSTEMS

HANDOUT 3: TYPES OF AIR CONDITIONERS

ROOM AIR CONDITIONERS

A room air conditioner can be installed either in a window or wall. There are many different models, designs, and styles of room air conditioners available ranging in size from small units able to cool just one room, to large units used to cool three or four rooms. Large units are often mounted through the wall and become permanent installations.

The big selection of air conditioners introduce a lot of problems. First, one must check the power consumption outlets, and voltages required by the various air conditioners. Then one must be concerned about the cooling capacity of the air conditioner to insure that it meets particular needs.

One of the biggest reasons an air conditioner does not perform to expectations is that the unit is simply too small for the area being cooled. The opposite problem, of course, occurs when a person buys an extra large air conditioner--one that has much more cooling capacity than is needed. A large unit makes too much noise, produces drafts, cools the room

too quickly, or does not seem to be able to lower the humidity of the air. All of these are common problems with oversized air conditioners, proving that bigger is not always better.

A large number of people buy a room air conditioner with the idea of cooling more than one room. The problem here may be improper air circulation. Cold air is heavy and difficult to move; it has a tendency to sink down next to walls and lie on the floor. A room air conditioner can provide only limited air circulation. It has a fan to blow the air out into the room, but it has no way to really circulate the air through the house. Cool air will not circulate by itself as readily as warm air, so you have to be sure that either the air conditioner's fan is able to blow the cool air into all rooms or provide an extra fan to assist the air conditioner.

If the air conditioner is installed in a room that has limited circulation to the other rooms in the house, such as a bedroom, the room with the air conditioner will be much cooler than the other rooms. Using fans to help circulate the cool air can bring the air conditioner's performance up to what it should be. Fans are beneficial in another way, for the air circulating from the fans will speed up evaporation from the body and make one feel cooler. He/she will probably see fit to turn the thermostat on the air conditioner to a warmer setting and save some electricity.

The performance of a room air conditioner depends, to some extent, on the place in the home chosen to have it installed. For example, if the air conditioner is installed in a window directly opposite a door, the fan on the air conditioner is going to blow cool air out the door each time it is opened. Certainly, this is no way to conserve energy and cool a room efficiently.

If a person wants to cool two or more rooms, it is desirable to locate the air conditioner opposite an open doorway to one of the other rooms.

CENTRAL AIR CONDITIONING SYSTEMS

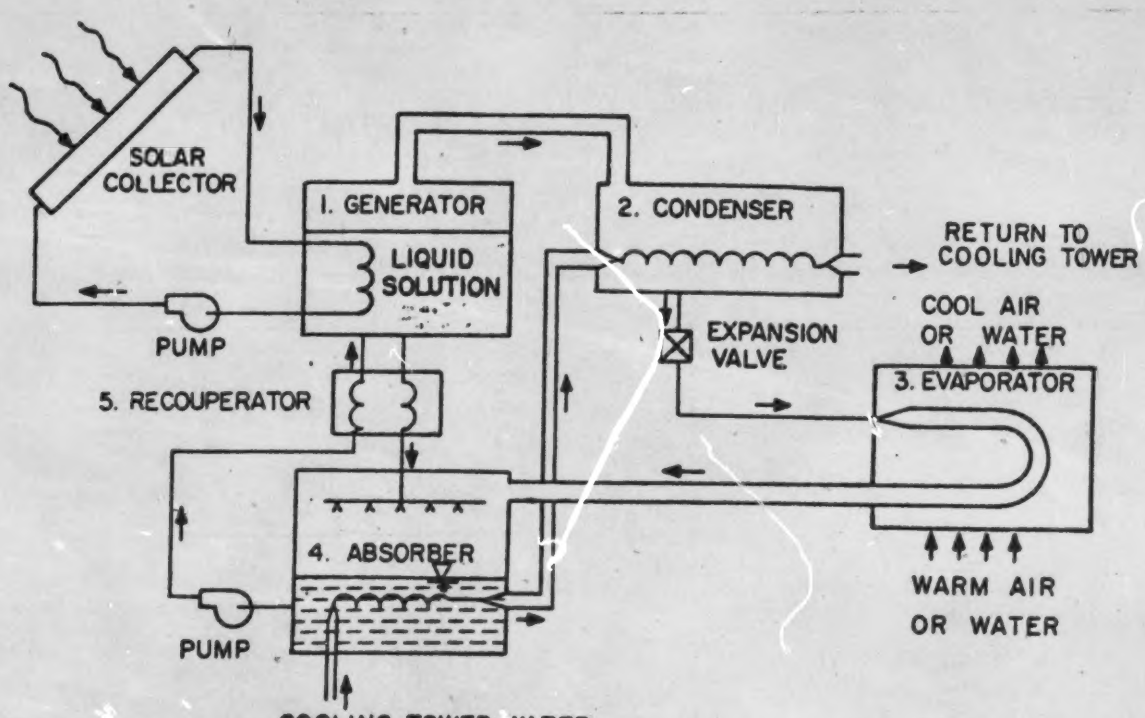
A central air conditioning system operates the same way as a room air conditioner. The components are the same and the operation is the same. A central air conditioner merely has larger parts and capacity and is designed to cool an entire house instead of one or a few rooms.

The evaporator coil is usually cased in the furnace component. The condenser is outside the house, connected to the evaporator by copper tubing carrying the refrigerant back and forth. An alternate type of central air conditioner is made as one unit, located outside the house and connected to the furnace duct system through a separate duct line.

ABSORPTION REFRIGERATION

An absorption refrigeration machine uses heat energy to provide cooling. When a liquid mixture of refrigerant and absorbent is heated, the refrigerant is driven out of solution. The refrigerant flows from the generator through a condenser, expansion valve, and evaporator, then into an absorber, where it recombines with the absorbent. In a lithium-bromide-water absorption machine, water is the refrigerant and lithium bromide is the absorbent. An absorbent is a liquid which combines chemically with the refrigerant at low temperatures but will separate from the refrigerant at high temperatures. In the combination process, heat absorbed by the refrigerant is released.

The operating principle of a lithium bromide absorption cycle is explained with the aid of the Schematic drawing below.

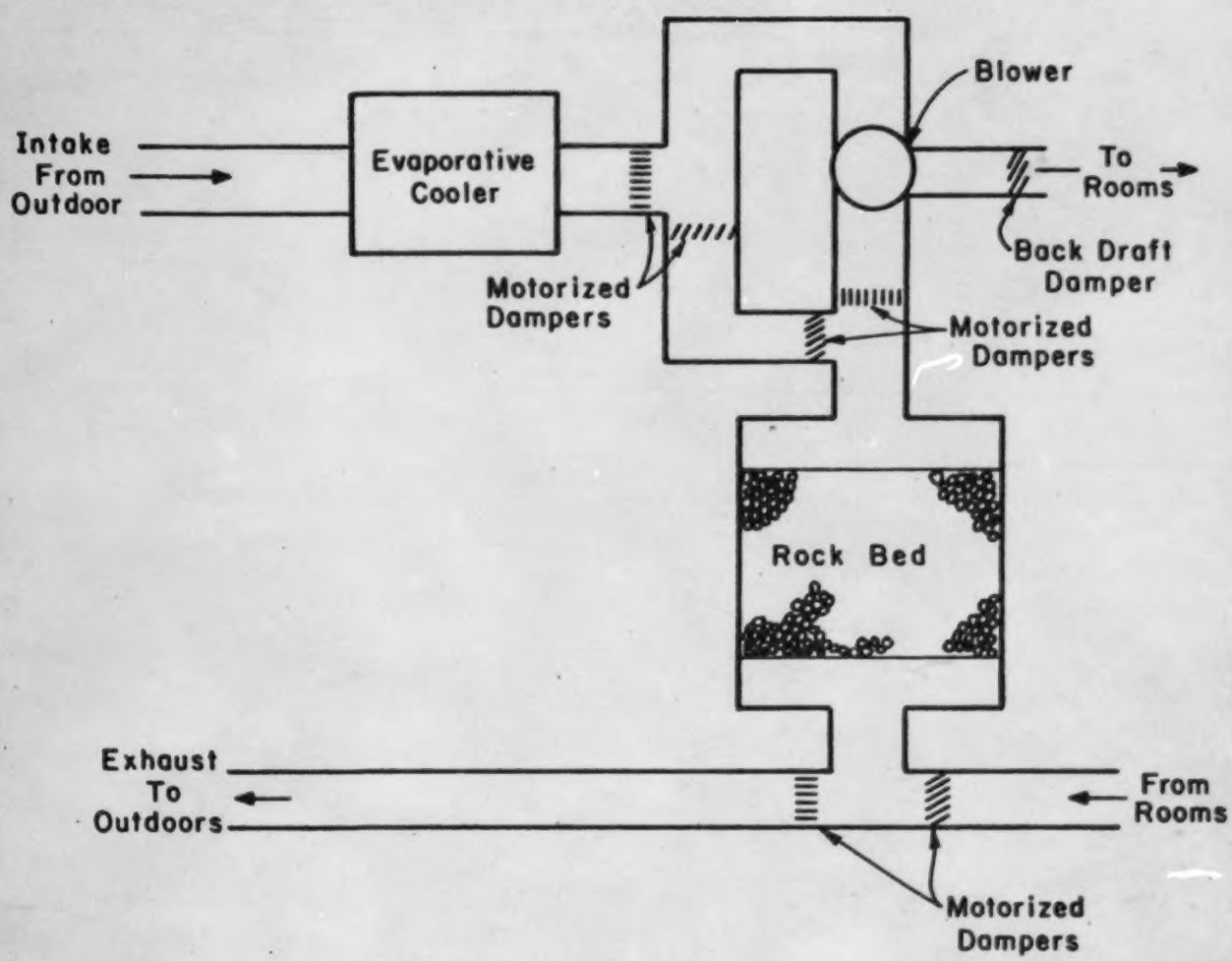


The cycle begins when water in the liquid mixture in the generator is boiled off and superheated with solar energy at temperatures between 170° and 210°F. Superheating of water is made possible by having very low pressure in the system. The superheated water vapor leaving the generator enters the condenser, where it is cooled to about 100°F by the cooling water from an outdoor cooling tower. The vapor condenses to a liquid and is then re-vaporized through an expansion valve which cools the vapor-liquid mixtures to a temperature of 40°F in the evaporator coils. The heat in the air or water which is brought in contact with the evaporator is removed by the cool refrigerant. The refrigerant then passes to the absorber where it recombines with the concentrated lithium-bromide solution from the generator at a temperature of about 100°F. In this recombination process, heat is released, and the heat is removed by the cooling water from the cooling tower. The dilute solution of lithium-bromide and water in the absorber flows by gravity, or is pumped, back to the generator and the cycle is repeated. The recouperator in the diagram is a heat exchanger which preheats the dilute solution as it flows from the absorber to the generator and at the same time cools the hot concentrated solution which flows from the generator to the absorber.

EVAPORATIVE COOLING THROUGH ROCK BED

A simple evaporator cooler can be used to cool warm air by passing the air through an air washer. Depending upon the velocity of air and wet-bulb temperature, warm air may be evaporatively cooled to a desired dry-bulb temperature. As an example, outside air at 100°F dry-bulb temperature and 70°F wet-bulb temperature (relative humidity 22 percent) can be cooled by an air washer to about 77°F. However, the relative humidity would be an uncomfortable 71 percent. Strictly speaking, evaporative cooling is not a solar system. However, because the rock bed of an air heating solar system can be used for storing "cool" in the summer, an evaporative cooling unit may be considered along with an air heating solar system.

An evaporative cooler coupled with a rock-bed storage unit is shown on the following page. Night air is evaporatively cooled and circulated through the rock bed to cool down the pebbles in the storage unit. During the day, warm air from the building can be cooled by passing the air through the cool pebble-bed. The dampers in the ducts are positioned to direct the circulation of air appropriately. When cooling is no longer achievable through the rock bed, the outdoor air can be cooled directly and delivered to the rooms. Evaporative cooling is practical only for arid and semi-arid regions where the relative humidity and night temperatures are normally low.



Evaporative Cooling with Rock Bed Storage

RADIATIVE COOLING

The use of a flat-plate collector to cool water or air by night radiation in the cooling season has been suggested as a possible way to cool a building. In principle, radiation from the absorber surface of a flat-plate collector to the cold night sky could cool the absorber surface and, hence, the water or air circulating through the collector. The difficulty with this method is that a good collector is a poor radiator, therefore, using the same collector which collects solar heat for the heating season to cool air or water in the cooling season is not practical.

There are two solar houses, one in California and the other in Arizona, that utilize evaporative cooling and nighttime radiation to regulate the temperature rise in residential buildings. The buildings have a shallow water pond on the roof with sectionalized retracting insulating covers over the pond. The covers are retracted at night to cool the pond by evaporation and radiation to the night sky. The covers are closed during the day to prevent solar heating of the pond. The cool pond absorbs the heat from the rooms below to keep the building space cool.

During the winter the shallow ponds are used for heating the building. The insulating covers are retracted during sunny days to collect solar heat in the pond and closed at

night to prevent excessive heat loss from the pond. The stored heat in the pond then radiates uniformly into the living space below. At special locations in our country, this type of heating and cooling system is effective. However, in freezing climates, there are obvious difficulties when the outdoor temperature is very low.

There is a variation of the system. Water in the radiative cooler on the roof of the house is cooled by evaporation and radiation. When the cold water in the storage tank can be cooled, the water is circulated to the radiative cooler. The radiative cooler, which is a water pond, will usually be dry during the day because when the pump is shut off, the water automatically drains into the cold water tank. An open cycle system such as this is subject to accumulation of debris and frequent cleaning will be necessary. Also, because the system will collect rainfall, an overflow must be provided to the storage tank, and in off-seasons, the melting snow should be suitably by-passed from the tank.

The building is cooled by circulating the cold water through a fan/coil unit. When the temperature of the water at the bottom of the cold water tank is too high for efficient operation, the fan/coil unit and circulation pump are shut off.

Because of the continuous evaporation from the shallow roof pond, frequent addition of make-up water is necessary.

Unless the water is drained and exchanged frequently, the salinity of the water will increase.

Draining of the shallow roof pond can be accomplished during the cooler seasons of the year when building air-cooling and/or dehumidification is not required. Because the temperature of rain water would be close to the wet-bulb temperature of the air, in most instances, rain would assist in the cooling effort. Snow and/or melting snow should cause no problems during the winter, provided that the pipe draining the roof pond is large enough and the storage tank is protected from freezing.

HEATING, VENTILATING, AND AIR CONDITIONING
CONSERVATION

UNIT III: COOLING SYSTEMS

HANDOUT 4: SIZING A COOLING SYSTEM

As with a heating system, "sizing" means simply the selection of cooling equipment that will have the right capacity (in BTU's) to properly cool a home. If there is a forced-air heating system already, adding central air conditioning for summer use will already include the necessary ductwork, etc. for distribution of the heated (or cooled) air. The only additional equipment to be selected will be the air conditioning unit (which will be installed as part of the heat-cooling system). However, if only for a central air conditioning system (without central heat), is desired, the cooling equipment must also include the necessary ductwork and registers.

Many people believe that comfort cooling calls for lowering the house temperature by 12^{o} to 15^{o} below the outdoor temperature, and that is all. This is an error.

Regardless of the outdoor temperature in summer, the indoor temperature should be in the neighborhood of 78^{o}, and the relative humidity should be about 50%. If it is any hotter or more humid than this, the overwhelming majority of

people will feel distinctly warm and uncomfortable, whether the outdoor temperature is 85° or 100°. Thus 75° and 50% relative humidity is said to be the ideal air condition for virtually all air conditioned spaces, including houses.

Home cooling systems should have enough capacity to provide this much cooling and dehumidifying at all times. This means that a larger cooling unit is needed for a house in Phoenix, where summer temperatures often climb to 105°, than is needed for an identical house in Chicago where outside temperatures seldom exceed 95°. It also means that more capacity is needed in a humid area like New Orleans than in a drier area like Chicago, having the same dry-bulb temperature.

The fact that we require 75° and a 50% relative humidity for bodily comfort in summer is based on staying in an air conditioned space for one or two hours or more. The same condition may feel overly cool when first entering an air conditioned store or restaurant. The longer one stays, however, the more our bodies adjust.

Therefore, it is a mistake to settle for a small air conditioner that can lower the indoor temperature to 80° only, or reduce indoor heat by only 12° to 15° below the outdoor temperature.

Each geographical location has a design temperature for cooling. This is not the highest temperature recorded...it

is the recommended high (dry-bulb) temperature on which to base practical cooling requirements. Find the design "Summer DB" temperature for your area, below. The same chart also lists wet-bulb "Summer WB" temperatures...which indicate the prevailing humidity conditions. In any area where the WB temperature does not exceed 75°, do not worry about the humidity; but if it does exceed 75°, increase the cooling unit capacity for proper humidity control.

DESIGN TEMPERATURES FOR AIR CONDITIONING
(OUTSIDE DRY AND WET BULB TEMPERATURES)

Major Kansas Cities	Summer DB	Summer WB
Atchison	100	76
Concordia	95	78
Dodge City	95	78
Iola	100	75
Leavenworth	100	76
Salina	100	78
Topeka	100	78
Wichita	100	75

Size is very important. If an air conditioner is too small, the air conditioner will run continuously on hot days and still not be able to cool the room. On the other hand, if the air conditioner is too large, the unit will start up and cool the area so quickly that it will only be on a short time. Consider the large amounts of electricity needed to start an electric motor and bring the air conditioner up to normal operation, the more often the compressor motor has to start, the more electricity will be wasted. Another result of short operating time is that the humidity in the room will not be lowered as much. Thus, the thermostat has to be set at a lower temperature for comfort, wasting more electricity.

Window air conditioners are sized in three ratings: horsepower, BTU, and tons of refrigeration (12,000 BTU is equal to one ton of refrigeration). A one horsepower unit provides about 8000 BTU depending on the efficiency of the unit.

An average size room with good insulation will usually require a unit rated at 8000 BTU, or 3/4 ton. A one-ton air conditioner will usually cool four or five rooms. These estimates depend, of course, on the air circulation in the house, its construction, insulation, and location.

As a rough estimate, one will need from 2.5 to 3 BTU for each square foot of floor space in a well insulated room.

Before purchasing a room air conditioner, measure the floor area of the rooms to be cooled. Also measure the window area and make a note of how much window area faces north, south, east, and west and whether or not the windows are shaded. Make a note of the number of appliances operating in the room and their wattages. Armed with these figures, estimate the right size unit for your needs. (See section of this unit which shows how to estimate cooling needs.)

Before going out to buy a room air conditioner check the wiring. While very small room air conditioners (4000 to 5000 BTU capacity) are not likely to require special wiring, air conditioners rated at 6000 BTU or more draw a considerable amount of electric current when they are starting up and operating. Therefore, be sure that the wiring in the home can handle the load.

Older homes often have circuits that can handle no more than 10 amperes, while most homes today have circuits rated for 15 or 20 amperes. A 6000 BTU air conditioner will typically require between 6 and 8 amperes, so even this relatively small unit will use a large percentage of the current capacity in one circuit of your home.

Large room air conditioners normally require 240V instead of the usual 120V found in most home outlets. The reason for this is that 240-volt operation needs only half

as much current to produce the same amount of power. Air conditioners are primarily 120-volt units until their current demands approach about 12 amperes; above this they normally use 240V. In terms of cooling capacity, this transition occurs somewhere between 8000 and 12,000 BTU, depending on the efficiency of the unit and on whether or not 240V is available. When air conditioners come in either 120V or 240V, the 240-volt unit is generally more efficient because the lower amount of current also wastes less energy in the motor wiring.

HEATING, VENTILATING, AND AIR CONDITIONING
CONSERVATION

UNIT III: COOLING SYSTEMS

HANDOUT 5: MAINTENANCE

The efficiency with which an air conditioner can dehumidify the air depends primarily upon how cold the evaporator coil gets. If the fan of the air conditioner is set at a low speed, the coil will get colder and more moisture will be removed from the air; however, the air conditioner may not be able to cool the house enough on especially hot days. At high fan speeds, the air conditioner will be able to cool better, but it will not be able to dehumidify as well. For best comfort place fan setting at 'low fan' on humid days and at 'high fan' on hot days.

Constantly adjusting the thermostat up and down does no good. An air conditioner will not cool a room any faster if the thermostat is set to a much cooler setting when it is first turned on. An air conditioner turns on when the thermostat senses that the room is too warm, and it does not turn off until the room is cool enough. The fastest way to cool a room is to set the fan speed on high. This will make the air conditioner work at maximum capacity. Set the thermostat

at a comfortable temperature, then leave it alone, except for minor changes to take care of cool or hot days. In general, an air conditioner with several fan speeds will permit the room to be kept at a more uniform temperature without having to adjust the thermostat as much.

Should one open up the house during the day when not at home? This is not a good idea if one lives in a climate with humid summers. If one closes up the house during the day, the temperature inside may increase, but the humidity will not--it will decrease. The temperature inside a sealed home will not become much hotter than it gets outside. This will permit the air conditioner to cool your home faster, and it will save electricity as well. As a general rule, if the humidity of the outside air is more than 30% it will be more economical to close up the house when leaving in the morning. The temperature inside the house may get as hot as the outdoors, but the lower humidity inside makes the home feel much cooler.

There are many things one can do to keep the air conditioning operating at peak efficiency. An air conditioner has filters that get clogged with dust, finned coils that become dirty, and motors that need lubricating. These simple tasks are not difficult to do and require only a wrench and a couple of screwdrivers.

All air conditioners should be lubricated and cleaned each year. The best time for doing this is a month or so before the summer cooling season begins.

As room air is drawn into the air conditioner it first passes through a foam or aluminum mesh filter much like the air filters in many furnaces. The air filters are cleanable, and they should be cleaned several times a year.

The evaporator coil at the front of the air conditioner rarely needs attention; the cleaning action of water condensing on it usually does a good job of keeping it free of dirt. However, one should routinely inspect this coil whenever he/she cleans the air filter. If the air filter has moved or allowed much dirt to pass through, sections of the evaporator coil may require some cleaning. After several years of use, some sections of the coil are bound to accumulate dirt.

If the thermostat on an air conditioner is set at a very low temperature, the evaporator coil may begin to ice up. What happens is that the temperature of the evaporator drops below the freezing point and ice begins to form on the evaporator. Ice usually starts to form along the refrigerant inlet at the top of the coil and it gradually progresses downward until the whole coil is blocked with ice. Since the formation of ice restricts the flow of air through the

evaporator coil, the more ice that forms, the colder the coil will get, and this causes even more ice to form.

The common reason for the evaporator icing up is setting the thermostat at too low a temperature. When the thermostat is set properly, the room will stay at a fairly comfortable and uniform temperature.

The moisture that collects on the evaporator drains back to a pan under the condenser coil. There, a ring on the fan blade often picks up the water and slings it onto the condenser. This technique increases the efficiency of the air conditioner because the evaporating water helps cool the condenser coil.

The condenser gets much dirtier than the evaporator. At most, a wire screen is used to keep out leaves and other large objects, but this still lets plenty of dirt and trash through to the condenser. To do a good cleaning job, the case should be removed from the air conditioner to get at all the parts inside.

Air conditioners normally have two motors, one for the fan and the other for the compressor. In this way, the fan motor can be running all the time to circulate air in the room, while the compressor motor need only run when the thermostat calls for more cooling. The fan motor may be single-shafted or double-shafted, depending on how the fan blades are connected to the motor. The most usual arrangement is

the double-shafted motor, in which the shaft extends from each end of the motor. A large fan blade is connected to one shaft of the motor to circulate air over the outside condenser coil. The other end of the shaft extends through a panel to a squirrel cage fan that circulates air over the evaporator coil and into the room. The advantage to using a squirrel cage fan on the inside is that it is much quieter in operation.

During the yearly tune-up, clean the fan motor and fan blades (particularly the condenser fan blades). The fan motor should be oiled too, though some of the newer fans have sealed bearings that do not require oiling every year.

Once a year, clean out the parts of a central air conditioner, the same as for a room air conditioner. The air filter should be cleaned or replaced about once a month. When the evaporator coil is located in the coil case of your furnace, the central air conditioner uses the furnace fan, so this fan will require more frequent inspection and cleaning. With the alternate, single-unit system, the central air conditioner contains a separate fan to force cool air into the furnace duct system. Electrically heated homes may use this alternate system with ductwork just for air conditioning.

Grass, leaves, and dirt may collect in the condensing unit located outside the house. Clean out the unit to remove any restrictions that could reduce the efficiency of

the unit or impair its operation.

Summer discomfort is largely caused by high humidity. The air's excess water content prevents sweat from evaporating and thus diminishes the body's natural cooling effect.

Removing excess water from the air in homes is possible without resorting to the expense of air conditioning. A dehumidifier is an apparatus that draws room air over a cooling coil where it loses moisture. Water is removed by condensation on cold coils. It is then heated slightly and returned by fan.

When buying a unit, look for the water removal capacity rating of the Association of Home Appliances Manufacturers. Humidifiers can range in price from $90 (with a water removal capacity of eleven pints a day) to $150 (with a 30 pint capacity and convenience features). The electrical operating rate can change from $.20 to $.50 per day. Operating costs are reduced when an area has been sufficiently dried and the machine does not have to run steadily.

For Safe, Efficient Operation-

-Read the owner's manual.

-Place the unit at least 6 inches (15cm) from the nearest wall for free air flow.

-Shut all doors and windows in the area to be dried.

-For the first few days, turn the humidistat to 'drier' or 'extra day'.

-Turn the machine off and disconnect power cord before emptying the water pans. Be sure the area and unit are dry before reconnecting the cord.

-On cool days, check the cold coils for frosting. Turn off until melted.

-Always unplug the cord before cleaning the unit. Dust the grills and wipe the cabinet.

-Every few weeks, clean the inside of the water container with a soft cloth and a mild detergent to prevent mold, mildew, and bacteria.

-Once a month, dust the lint from the cold coils.

HEATING, VENTILATING, AND AIR CONDITIONING
CONSERVATION

UNIT III: COOLING SYSTEMS

HANDOUT 6: TIPS FOR COOLING ENERGY SAVERS

The following tips for cooling energy savers are from the U.S. Department of Energy and serve as a convenient summary for the points discussed in this unit.

1. Over cooling is expensive and wastes energy. Do not use or buy more cooling equipment capacity than you actually need.
2. If you need central air conditioning, select the smallest and least powerful system that will cool your home adequately. A larger unit than you need only costs more to run but probably will not remove enough moisture from the air.
3. Ask your dealer to help you determine how much cooling power you need for the space you have to cool and for the climate in which you live. (For further information, see copies of Energy Efficiency Ratios.)
4. Make sure the ducts in your air conditioning system are properly insulated, especially those that pass through the attic or other uncooled spaces. This could save you almost 9 percent in cooling costs.

5. If you do not need central air conditioning, consider using individual window or through-the-wall units in rooms that need cooling from time to time. Select the smallest and least powerful units for the rooms you need to cool. As a rule, these will cost less to buy and less to operate.
6. Install a whole-house ventilating fan in your attic or in an upstairs window to cool the house when it is cool outside, even if you have central air conditioning.
7. It will pay to use the fan rather than air conditioning when the outside temperature is below 82 degrees. When windows in the house are open, the fan pulls cool air through the house and exhausts warm air through the attic.

When You Use Air Conditioning

1. Set your thermostat at 78 degrees, a reasonably comfortable and energy-efficient indoor temperature.
2. The higher the setting and the less difference between indoor and outdoor temperature, the less outdoor hot air will flow into the building.
3. If the 78°F setting raises your home temperature 6 degrees (from 72°F to 78°F, for example), you should save between 12 and 47 percent in cooling

costs, depending on where you live.

4. Do not set your thermostat at a colder setting than normal when you turn your air conditioner on. It will not cool faster, it will cool to a lower temperature than you need and use more energy.
5. Set the fan speed on high except in very humid weather. When it is humid, set the fan at low--you will get less cooling but more moisture will be removed from the air.
6. Clean or replace air conditioning filters at least once a month. When the filter is dirty, the fan has to run longer to more the same amount of air and this takes more electricity.
7. Turn off your window air conditioners when you leave a room for several hours. You will use less energy cooling the room down later than if you had left the unit running.
8. Consider using a fan with your window air conditioner to spread the cooled air farther without greatly increasing your power in use. But be sure the air conditioner is strong enough to help cool the additional space.
9. Do not place lamps or TV sets near your air conditioning thermostat. Heat from these appliances is

sensed by the thermostat and could cause the air conditioner to run longer than necessary.

With Or Without Air Conditioning

1. Keep out daytime sun with vertical louvers or awnings on the outside of your windows, or draw draperies, blinds, and shades indoors. You can reduce heat gain from the sun by as much as 80 percent this easy way.
2. Keep lights low or off. Electric lights generate heat and add to the load on your air conditioner.
3. Do your cooking and use other heat-generating appliances in the early morning and late evening hours whenever possible.
4. Open the windows instead of using your air conditioner or electric fan on cooler days and during cooler hours.
5. Turn off the furnace pilot light in summer, but be sure it is re-ignited before you turn the furnace on again.
6. Dress for the warmer indoor temperatures. Neat but casual clothes of lightweight openweave fabrics are most comfortable.
7. A woman will feel cooler in a lightweight skirt instead of slacks. A man will feel cooler in a

short-sleeved shirt than in a long-sleeved shirt of the same weight fabric.

Without Air Conditioning

1. Be sure to keep windows and outside doors closed during the hottest hours of the day.
2. Use windows or whole-house ventilation fans to cool the house when it is cool outside.
3. Use vents and exhaust fans to pull heat and moisture from the attic, kitchen and laundry directly to the outside.

If everyone raised air conditioning temperature 6 degrees, we would save the equivalent of 36 billion kilowatt-hours of electricity used in the nation in 1 year.

HEATING, VENTILATING, AND AIR CONDITIONING CONSERVATION

UNIT IV: DUCTING

UNIT OBJECTIVES

Upon completion of this unit the student will be able to:

1. Calculate duct size needed to supply conditioned air to various rooms in a home.
2. Distinguish between types of ducts and duct material.
3. Discuss the operating specifications of ducts and registers.
4. Discuss various duct piping arrangements for certain types of building constructions:
   a. Extended Plenum System
   b. Radial Piping System
5. Recognize the importance of duct insulation.

HEATING, VENTILATING, AND AIR CONDITIONING
CONSERVATION

UNIT IV: DUCTING

HANDOUT 1: INTRODUCTION TO DUCTING
(SIZING AND TYPES)

In a central heating or central cooling system, the delivery system for the conditioned air is through duct work.

The specific type of duct system used depends upon the type of structure, the equipment location and the layout of the building. Ideally, the furnace should be located near the center of the house. This will eliminate long runs of ducts, which is more important since conditioned air passing through long ducts will lose or gain considerable heat before reaching its destination. Also, long ducts increase the incidence of friction between the air and the sides of the ducts, which causes more energy loss.

Single-story houses may have the ductwork terminating in registers delivering air from either the floor, walls or the ceiling. However, it is recommended that overhead distribution be used only in mild winter climates unless some provision is made to heat the floors in a cold climate.

CALCULATION OF DUCT SIZE

Duct sizes are determined according to airflow rates in CFM (cubic feet per minute). Size is determined by the amount

of air that is required to either heat or cool a room. The general formula is $S/sf = \frac{V}{AF}$ where S is the size in square feet, V is the volume of air required and A/F is the air flow in feet per minute (usually 600 fpm in the average room). V is determined by several factors including heat loss temperature of the air coming off the furnace or air conditioner and the overall volume of the room. Generally speaking, air conditioning ducts must be larger than heating ducts. Ducts are commonly rectangular or circular in cross section, and are usually designed for velocities of 150 to 1500 feet per minute (fpm).

Cost of duct work varies. As a rule of thumb, at present prices, ductwork is estimated at $75 - $100 per room register.

TYPES OF DUCTS

Ducts are usually made of:

Galvanized steel sheet
Black-iron sheet
Stainless-steel sheet
Aluminum sheet
Fibrous glass sheet

Heating ducts are usually 6" in diameter and cooling ducts 8".

The common functions of ducts and their operating specifications are:

Air intake from outside	500-1200 CFM

Air washers (dust removers)	500- 600 CFM
Branch ducts and risers	500-1800 CFM
Exhaust risers	500-1800 CFM
Heater corrections	700-1400 CFM
Humidifiers	500- 600 CFM
Main Exhaust ducts	900-1500 CFM
Main Ventilating ducts	500-1500 CFM
Supply grilles near floor	150- 250 CFM
Supply openings	350- 500 CFM
Supply registers and grilles	250- 450 CFM

HEATING, VENTILATING, AND AIR CONDITIONING
CONSERVATION

UNIT IV: DUCTING

HANDOUT 2: DUCT SYSTEM DESIGN

There are several techniques to consider in designing a good energy saving duct system. Sharp turns should be eliminated when possible in order to cut down on pressure losses that will occur when fast moving air is forced to turn a corner. Turning vanes should be installed inside elbows where sharp turns are necessary.

Ducts should be properly sized for the blower. If undersized, the air will move too fast through the ducts causing unwanted noise and excessive losses due to air friction along the duct walls. Long runs of ducts should be eliminated to avoid friction losses, also.

Location of the vents is also important. In a home where heating is the most important consideration due to long cold winters, warm air should enter the room near the floor so that the heat will rise by convection. The return air vents should be placed high on the walls and on opposite sides of the room. This allows the incoming warm air to rise from the floor and travel across the room.

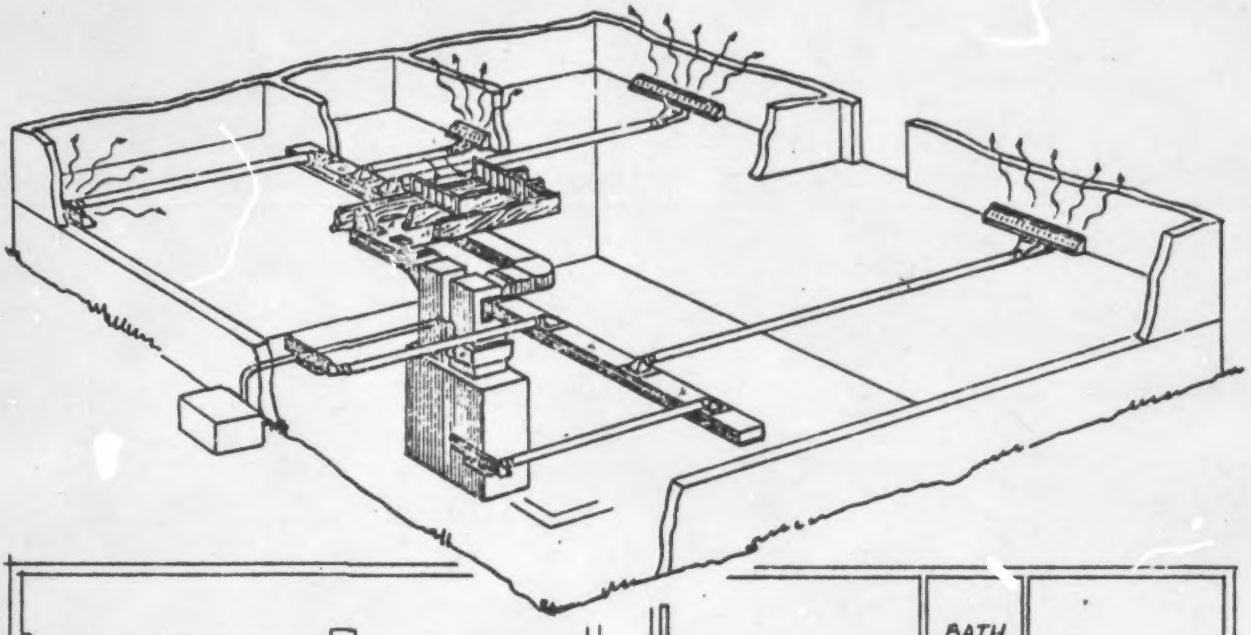
Zoning of heating and cooling systems almost always pro-

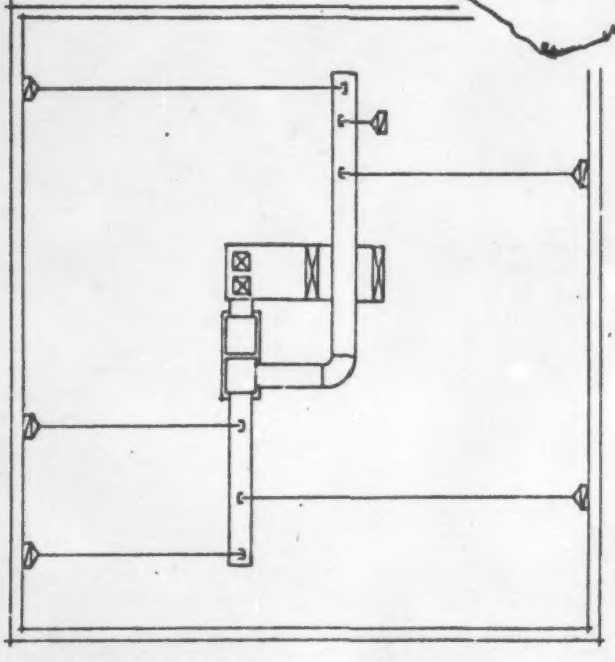
vides the opportunity for lower energy consumption, since each zone can be maintained at the temperature required, without regard to the temperatures in other zones. Zoning also provides the owner with the opportunity to cut back on the heating and/or cooling to any rooms not being used. Tests have shown that zoning can achieve energy savings of 20% and more.

The following pages show various duct piping arrangements for certain types of building constructions.

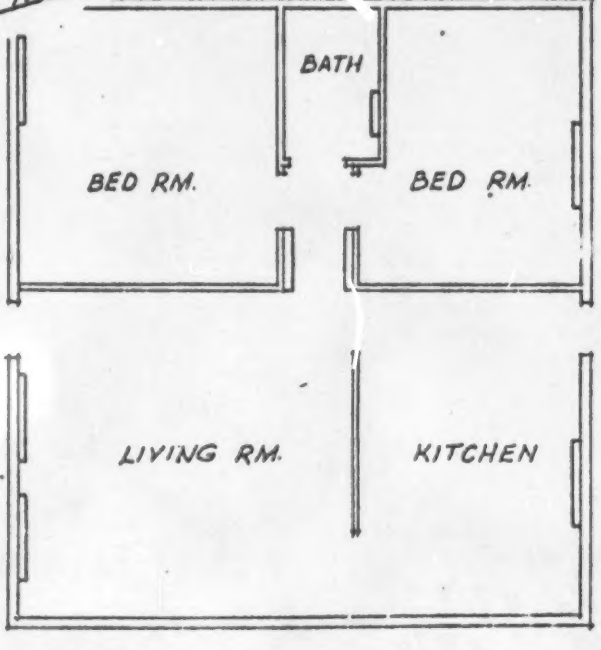
EXTENDED PLENUM SYSTEM

The extended plenum system usually is preferred for basement installation because of its neat appearance. Branch pipes to outlets may be round or rectangular and are run between or beneath basement joists. The extended plenum is usually required for larger installations.





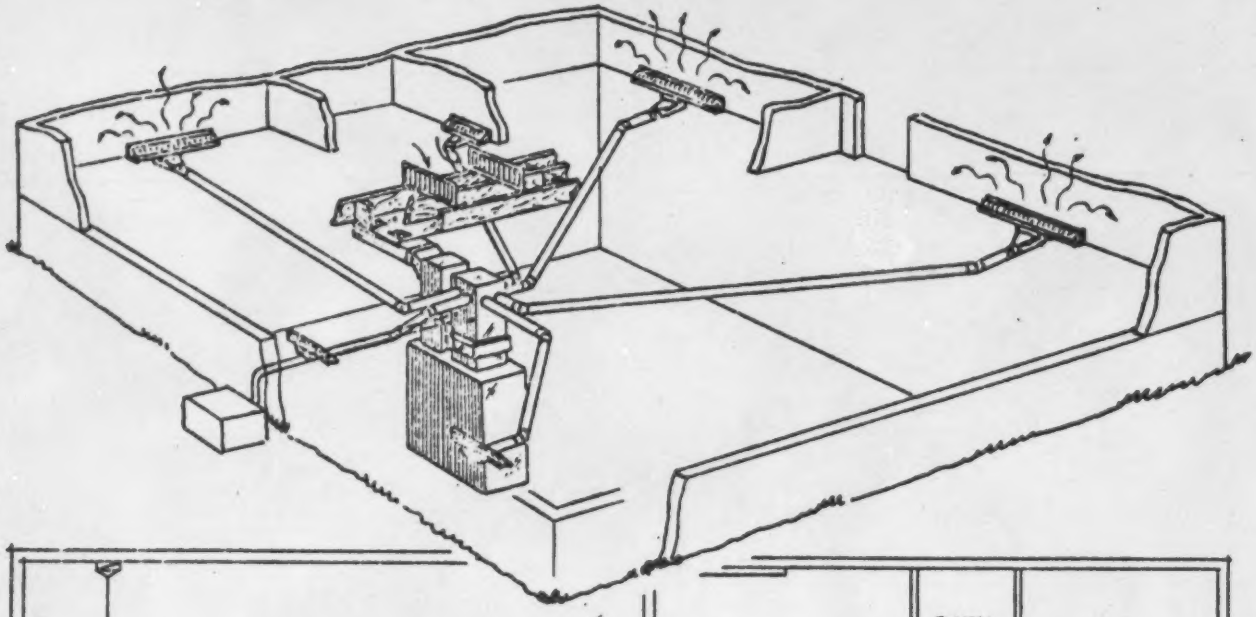
BASEMENT PIPING PLAN

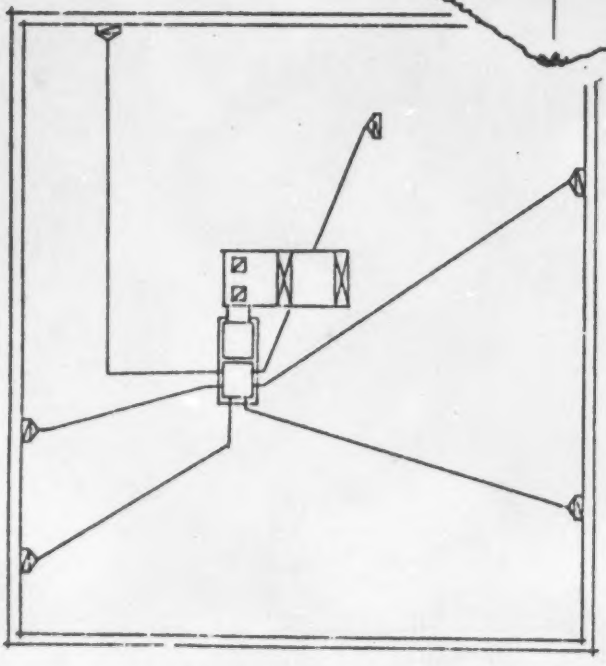


FIRST FLOOR PLAN

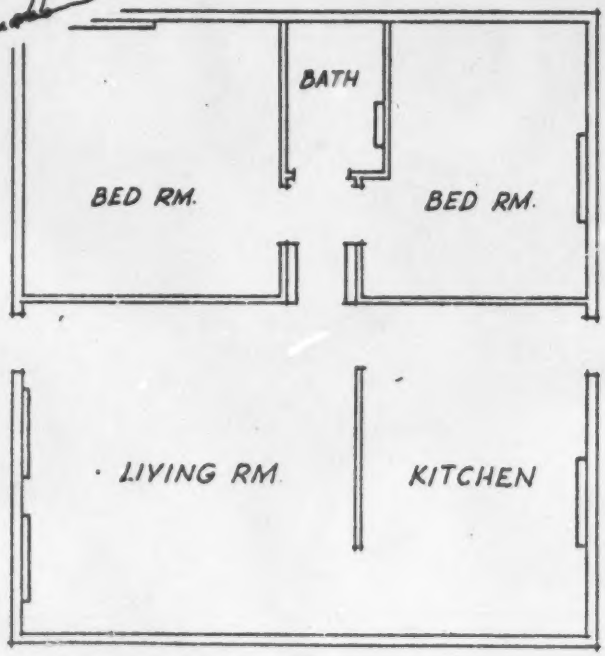
RADIAL PIPING SYSTEM

This method of piping can be used where length of individual pipe runs does not exceed limits of pipe capacity and where appearance is not a factor. Pipes are suspended from basement joists and run in as direct a line as possible from plenum to outlet connection. Requires a minimum amount of pipe.





BASEMENT PIPING PLAN

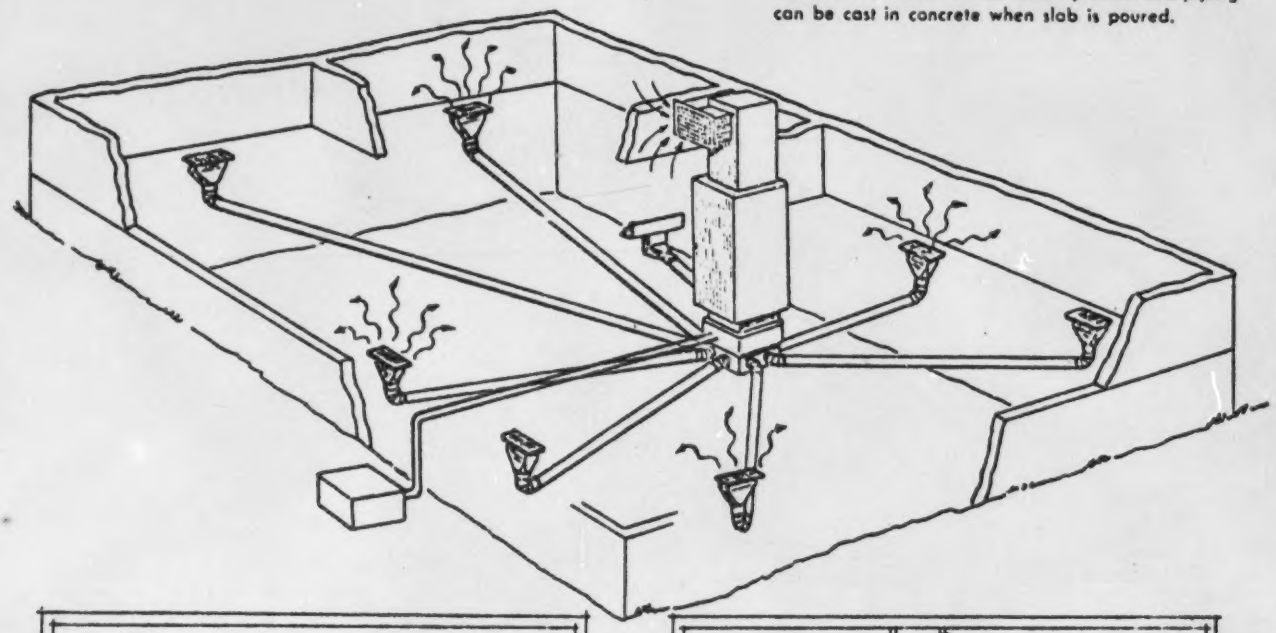


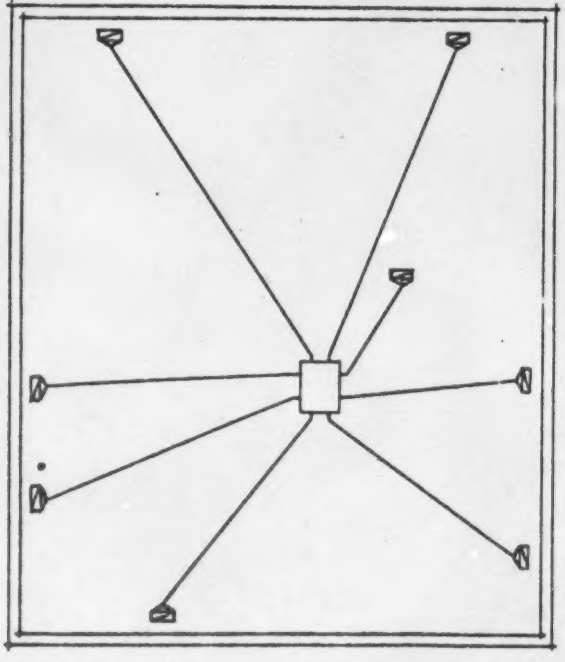
FIRST FLOOR PLAN

ONE-STORY HOUSE
WITH CRAWL SPACE

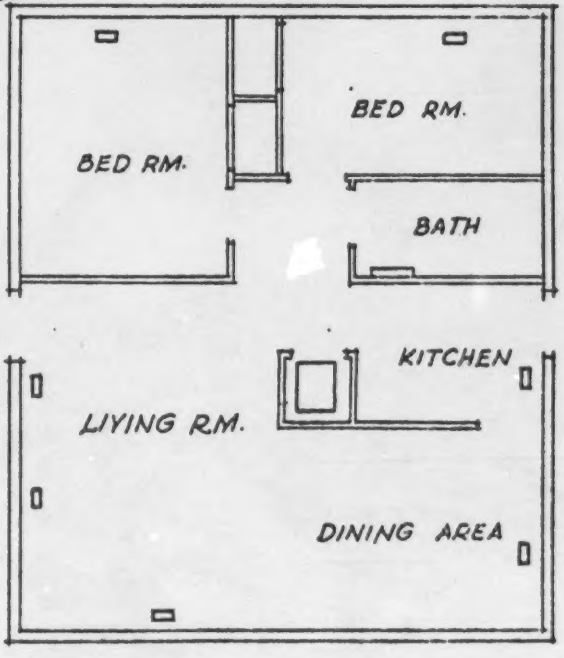
RADIAL PIPING SYSTEM, COUNTERFLOW FURNACE

This combination is widely used in compact, one-story houses with crawl space. Warm air plenum under furnace extends into crawl space, where pipes to supply outlets are run beneath joists. Supply pipes and plenum should be insulated. Similar system is used with slab construction where plenum and piping can be cast in concrete when slab is poured.





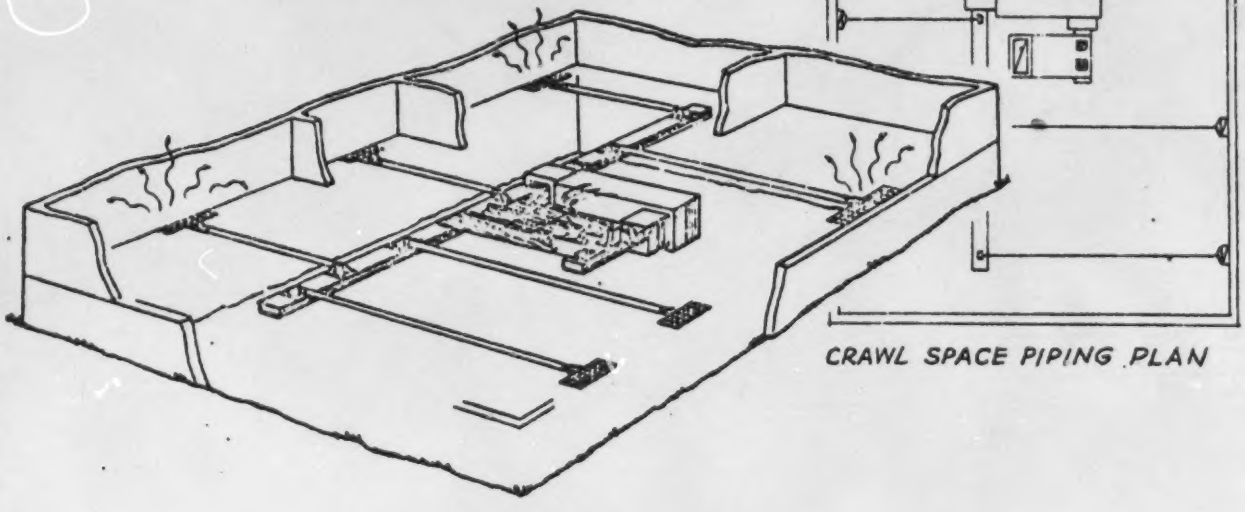
CRAWL SPACE PIPING PLAN



FIRST FLOOR PLAN

HORIZONTAL FURNACE SYSTEM

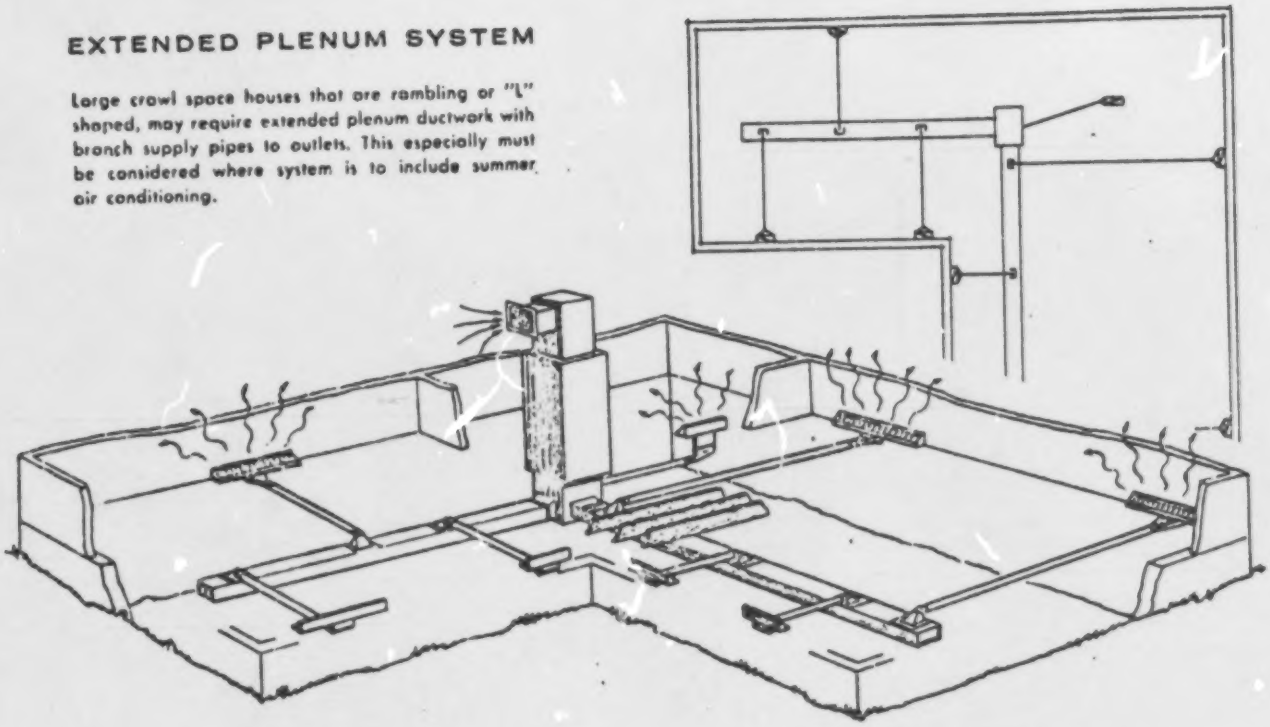
In some cases, where there is sufficient height, a horizontal oil or gas furnace is suspended from joists in crawl space. Extended plenum or radial type supply distribution piping may be used. Plenum, ducts and pipes should be insulated.



CRAWL SPACE PIPING PLAN

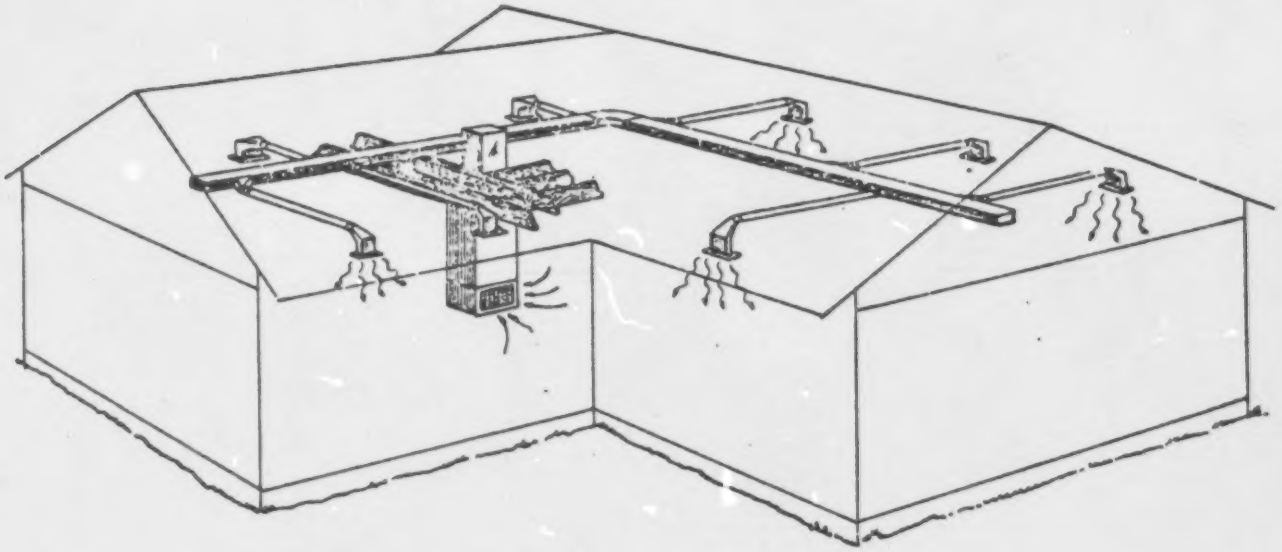
EXTENDED PLENUM SYSTEM

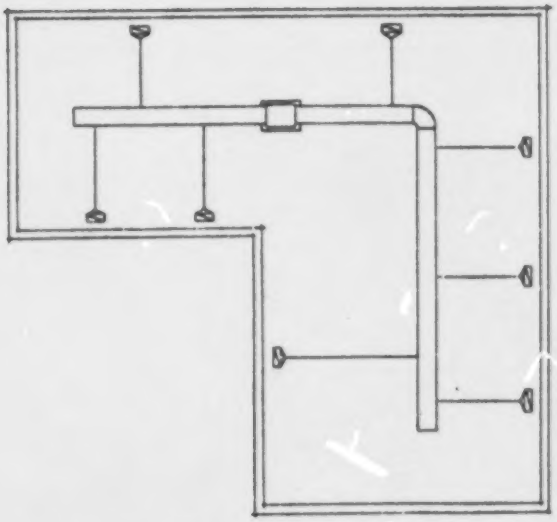
Large crawl space houses that are rambling or "L" shaped, may require extended plenum ductwork with branch supply pipes to outlets. This especially must be considered where system is to include summer air conditioning.



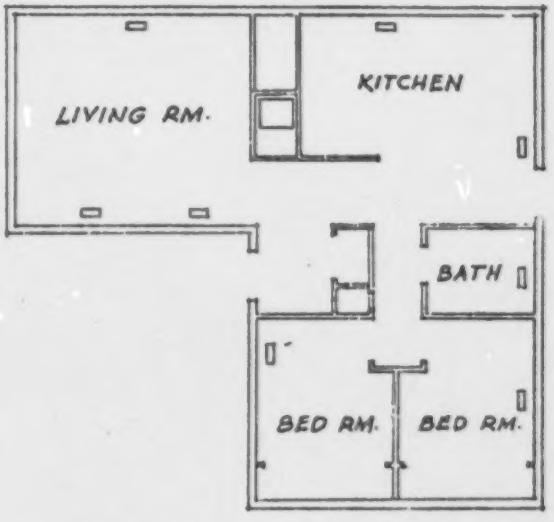
EXTENDED PLENUM IN ATTIC

Unless furnace plenum and supply pipes are cast in the concrete when slab is poured, piping for this type of house must run in the attic. Ducts and piping run across top of joists. Floor diffusers are turned upside down and installed in ceiling near outside walls. Round diffusers centered in room ceilings may be used. Plenum and piping must be insulated.





ATTIC PIPING PLAN



FIRST FLOOR PLAN

HEATING, VENTILATING, AND AIR CONDITIONING
CONSERVATION

UNIT IV: DUCTING

HANDOUT 3: DUCT INSULATING

The ducts used to heat and air condition a home can be a major source of energy loss. In the winter, heat energy is lost from the ducts into cooler, unheated spaces; in the summer, heat energy is absorbed by the air conditioning ducts passing through non-insulated spaces. Air conditioning ducts are also susceptible to water condensation, and this can rust out a duct system in just a few years.

In heating systems, a duct running through any unheated area, such as an attic, garage, or unheated crawl space, should be insulated to reduce heat loss. While special duct-wrapping insulations are available for this purpose, you might find it more economical to use regular batting insulation. Normally, two inches or more of insulation is needed to adequately insulate heating ducts. The insulation should have a protective covering or backing; although a vapor barrier is usually not required over the outside of the insulation if the duct is used only for heating. If the heating ducts run through an insulated crawl space, the ducts will not usually require insulation. In the winter, the crawl space should be

high enough to prevent much heat loss through the exposed ducts.

Many new types of duct material are available. One type consists of fiberglass sheets that can be folded into a rectangle and taped in shape. The ends of each section are then notched and the pieces fitted together (like two pieces of pipe) and the seams are then taped to prevent air leakage. This fiberglass is manufactured with a vapor barrier covering (usually silver in color).

When air conditioning ducts run through any area that is not temperature controlled, the ducts must be insulated and covered with a vapor barrier. Exposed air conditioning ducts not only increase your cooling load, they also cause the warm surrounding air to condense water vapor on the ducts, and this encourages rusting and other moisture problems. During the cooling season, the crawl space is generally cool enough that no moisture will condense on the ducts. If you do have a condensation problem, a simple solution is to cut an outlet in the duct system to blow some cool air into the crawl space. This method normally results in an insignificant increase in your cooling load because the crawl space is sealed, insulated and fairly cool to begin with. Just install a vent in the duct outlet so that you can regulate the amount of cool air that enters the crawl space, and be sure to close the vent during the winter heating season.

MODULE #9

HEATING, VENTILATING, AND AIR CONDITIONING CONSERVATION

TERMINOLOGY GLOSSARY

Absorption -- A process whereby heat extracts one or more substances present in an atmosphere or mixture of gases or liquids, accompanied by physical change, chemical change, or both changes of the material.

Absorption chiller -- A refrigeration unit based upon absorption refrigeration.

Absorption refrigeration -- Cooling which is effected by the expansion of liquid ammonia into gas by water. Heat is the primary source of energy.

Active -- When applied to building design, it refers to the mechanical movement of energy by the use of an external force of energy.

Air change -- The movement of a volume of air in a given period of time; if a house has one air change per hour, it means that all the air in the house will be replaced in a one-hour period. Air changes are expressed in cubic feet per minute.

Air conditioning -- The process of treating air to control its temperature, humidity, flow, and odor.

Ambient temperature -- Temperature of the outside air.

Attic ventilation -- In houses, screened openings provided to ventilate an attic space. They are located in the soffit area as inlet ventilators and in the gable end or along the ridge as outlet ventilators. They can also consist of powerdriven fans used as an exhaust system.

Berm -- A mound or small hill of earth, man-made.

British Thermal Unit (BTU) -- The amount of heat necessary to raise the temperature of one pound of water one degree Fahrenheit; a unit of heat roughly equal to the amount of heat given off by burning a kitchen match.

Building skin -- The physical structure which encloses a building.

Bypass loop -- A piping arrangement which bypasses or circles the flow of a heat absorbing medium around rather than through a piece of mechanical equipment.

CFM -- An abbreviation for cubic feet per minute.

Capacity -- The usable output of a system.

Centrified fan -- A machine for moving a gas, such as air, by accelerating it rapidly outward in an impeller to a surrounding casing; generally of a scroll shape.

Change of state (phase change) -- The change from solid, or gas to either of the other two.

Chimney effect -- The tendency of air or gas in a duct or other vertical passage to rise when heated due to its lower density compared with that of the surrounding air or gas. In buildings, the tendency toward displacement (caused by

the difference in temperature) of internal heated air by unheated outside air due to the difference in density of outside and inside air.

Coil -- A cooling or heating element made of pipe or tubing.

Comfort zone -- The ranges of indoor temperature, humidity, and air movement under which most persons enjoy mental and physical well-being.

Compression -- In a compression refrigeration system, a process by which the pressure and temperature of the refrigerant is increased to allow for greater heat transfer.

Conduction -- A process of heat transfer whereby heat moves through a material.

Convection -- Transfer of heat by movement of a fluid or gas.

Crack method -- A method used in the calculation of air movement from the outside into an enclosed space. The method is based on the rate through one foot of crack between sash and frame or between door and frame.

DHW tank -- Abbreviated form for Domestic Hot Water tank.

Damper -- A device used to vary the volume of air passing through an air outlet, inlet or duct.

Dehumidification -- The condensation of water vapor from air by cooling below the dew point or removal of water vapor from air by chemical or physical methods.

Density -- The weight per unit volume.

Diurnal cycle -- The day-to-night change or cycle of natural

phenomenon. An example is the variation of outdoor temperature throughout a twenty-four hour period.

Dry bulb temperature -- A measure of the sensible temperature of air (the one with which we are most familiar).

Economizer cycle -- A cooling mode which uses cool outdoor air to offset heat gains in buildings rather than using an energy consuming cooling device.

Electronic air filter -- The use of electricity to set up a static charge which can remove dust and other particulate matter.

Energy -- The capacity for doing work; taking a number of forms which may be transformed fron one into another, such as thermal (heat), mechanical (work), eletrical and chemical; in customary units, measured in kilowatt hours (KWH) or British Thermal Units (BTU); in SI units, measured in joules (J), where 1 joule = 1 watt-second.

Enthalpy -- A measurement of the total energy content of the air. The total energy content is composed of both sensible and latent heat as measured by the dry bulb and wet bulb temperatures.

Evaporative cooling -- Lowering the temperature of a large mass of liquid by utilizing the latent heat of vaporization of a portion of the liquid; cooling air by evaporating water into it.

Flow rate -- Velocity at which a fluid travels, usually through an opening or duct.

Frequency of occurrence -- The number of times a given event will occur during a given period of time.

GPM -- An abbreviation for gallons per minute.

Greenhouse effect -- The effect of the earth's atmosphere in trapping heat from the sun. The atmosphere acts like a greenhouse by admitting the sun's shortwave radiation but blocking the exit of long wavelength radiation re-emitted by the earth or other warmed objects.

Heat capacity -- Sometimes called the thermal capacity, a measure of how much heat is required to raise the temperature of a specific quantity of material by a given amount.

Heat dissipator -- The method of transmitting energy or power out of a system in the form of heat.

Heat exchanger -- A device used to transfer heat from one medium to the other.

Heat gain -- An increase in the amount of heat contained in a space, resulting from direct solar radiation and the heat given off by people, lights, equipment, machinery, and other sources.

Heat loss -- A decrease in the amount of heat contained in a space, resulting from heat flow through walls, windows, roof, and other building envelope components.

Heat pump - A reversible refrigeration system that delivers more heat energy to the end use than is put in to the compressor. The additional energy input results from the absorption of heat from a low temperature source--the combination heating and cooling unit. It operates like a

normal air conditioner in summer, and in winter operates in reverse, cfecting warm air indoors and cool air (or water) outdoors.

Heat wheel -- A device used in ventilating systems which tends to bring incoming air into thermal equilibrium with existing air. As a result, hot summer air is cooled and cold winter air is warmed.

Humidifier -- A device to add moisture to air.

In-line pump -- A pump which is supported by the piping system.

Incident -- Usually used in the term "incident radiation" which is the amount of energy striking a collector surface before entering the collector.

Infiltration -- The uncontrolled flow of air into and out of a building through cracks, openings, doors, or other areas which allow air to penetrate.

Initial cost -- The original price of an item or system.

Insulation, thermal -- Any material high in resistance to heat transmission that, when placed in the walls, ceilings, or floors of a structure, will reduce the rate of heat flow.

Kilowatt Hour (KWH) -- Unit of electrical energy consumption which equals about 3,400 BTU.

Latent heat -- A change in heat content that occurs without a corresponding change in temperature, usually accompanied by a change of state.

Peak load -- Maximum predicted energy demand of a system.

Perms-permeance - The ratio of water vapor flow to the vapor

pressure difference of the surfaces; permeance is expressed in perms or (grains)/(Sq.Ft.)(Hr.), and of mercury vapor pressure difference.

Psychrometric -- Pertaining to the device comprising two thermometers, one a dry bulb, the other a wet bulb or wick-covered bulb, used in determining the moisture content or relative humidity of air or other gases.

R-value resistance -- The resistance of a material to the flow of heat or energy.

Relative humidity -- The ratio of the amount of water vapor at a given temperature to the maximum amount of water vapor that could be held as vapor.

Sensible heat -- Heat that results in a temperature change.

Set back -- The lowering of the thermostat setting. The technique is used to reduce the amount of heat required to heat a space.

Set up -- The raising of the thermostat setting. The technique is used to reduce the amount of cooling required to cool a space.

Shortwave radiation -- A term used loosely to distinguish radiation in the visible and near-visible portions of the electromagnetic spectrum (roughly 0.4 to 1.0 micrometers in wavelength) from longwave radiation (infra-red radiation).

Sling psychrometer -- A psychrometer in which the wet and dry bulb thermometers are mounted upon a frame and connected to a handle at one end by means of a bearing or a length

of chain. It may be whirled in the air for the simultaneous measurement of wet and dry bulb temperatures.

Solar intensity -- The amount of solar radiation.

Solenoid value -- A value actuated by a solenoid or an electronic impulse for controlling the flow of gases or liquids in pipes.

Space heating -- Interior heating of a building or room.

Stagnation -- The condition of a fluid or gas unstirred by a current or flow.

Thermal comfort -- The zone in which a majority of the human population would not feel too hot or too cold.

Thermal lag -- The ability of materials to delay the transmission of heat; can be used interchangeably with time lag.

Thermal sensation -- The ability of the body to sense the temperature as being too hot or too cold.

Time lag -- The time between a cause and a resultant effect, as between occurrence of heat input on an exterior surface of a wall and the time until the heat is transmitted to the interior wall surface.

Ton (of air conditioning) -- The thermal refrigeration energy required to melt one tone of ice (2,000 pounds); equals 12,000 BTU.

"U" value -- A coefficient which indicates the energy (BTU) which passes through a component for every degree (Fahrenheit) of temperature difference from one side to the other under steady state conditions.

Vapor barrier - A component of construction which is impervious

to the flow of moisture or air.

Vapor pressure -- The force exerted when moist air attempts to seek equilibrium by migrating to areas with less water vapor.

Ventilation air -- Outside air that is intentionally allowed to enter an interior space.

Weatherstripping - Foam, metal, or rubber strips used to form a seal around windows, doors, or openings to reduce infiltration.

Wet bath temperature -- The lowest temperature attainable by evaporating water into the air, without altering the energy content.

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FULL CIRCLE. 1978. 20 minutes, 78 slides with cassette, $85 for slides/purchase; $10 for cassette/purchase.

THE GREAT ADVENTURE. Monumental Films for the U.S. Department of Energy (DOE) Office of Consumer Affairs; 1979. 28-½ minutes, 16 mm, color, $162.50/purchase; free loan.

HERE COMES THE SUN. National Science Foundation; 1974. 15 minutes, 16 mm, color, $87/purchase; free loan.

LOOK TO THE SUN. 1977. 12-½ minutes, 16 mm, color, $69.50/purchase; free loan.

PUTTING ENERGY ALTERNATIVES TO WORK. 1977. 15 minutes, 16 mm, color, $185/purchase; $25/rental.

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INSTALLING SOLAR HEATING AND DOMESTIC HOT WATER SYSTEMS. 75 slides, 35 mm, 15 minute audio cassette, P.O. Box 1607, Rockville, Md. 20850.

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FLAT-PLATE SOLAR COLLECTORS, Part I and Part II, videotape, 116 minutes; DESIGN AND INSTALLATION OF SOLAR HEATING AND COOLING SYSTEMS, Part I and Part II, videotape, 104 minutes; ITT/V, ITT center, Chicago, Ill. 60616.